POWER

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Purposeful Anecdotes

Are You Getting All You Are Worth?

A YOUNG man who was employed on a small salary by an engineering firm felt sure he was worth more money than he was getting. He consulted an older man for advice. After listening to a long list of "reasons why," the elder man addressed him thus:

"You really believe you are worth more to your employer? Very well; we shall see. Go back to your work for one month, and try to think of some way to increase your firm's sales, say one hundred dollars during the next thirty days."

At the end of the month the young man reported that he had been unable to think of any means for doing this.

"All right," said his adviser. "Go back for another month and try to think of some way to reduce your firm's expenses, say fifty dollars a month."

The young man couldn't suggest anything so had to report failure again.

"Can't you think of some way to reduce their expenses even five or ten dollars a month?" continued the man of affairs.

The youth shook his head—he couldn't offer a single suggestion that would save his employer even *one* dollar a month.

"Then listen," said the older man. "Go back to your work and make yourself as inconspicuous as possible, for you are indeed fortunate and don't know it. You are unable to increase the sales or reduce the expenses a single dollar a month, yet you are drawing out your salary every week. Your name on the payroll is likely to be cited any minute as an item of *expense* and ordered removed. These are the problems your employer has to shoulder every day of his life, and *you* are just so much more load for him to carry. Lay low, my boy, lest he discover that he can do *without* you until you can be of some real benefit to him."

Contributed by C. N. KELSEA, *Lynn, Mass.*

Gas-Power Plant of the Illinois Glass Co. at Alton

By Thomas Wilson

SYNOPSIS—Suction gas-producer plant of 1000-hp. capacity, supplying gas from Southern Illinois coal to engines rated at 950 hp. Spun-glass filters cleanse gas of tar, which is burned in furnaces of boiler plant. A 3000-hp. suction producer, said to be the largest in the world, supplies gas to annealing ovens and to the power plant if necessary. Initial and operating costs of the power plant are given.

Forty-five years ago the Illinois Glass Co., of Alton, started to make bottles with one little furnace. As business increased the plant was enlarged until in 1910, the employees numbered 3500 and twelve tank furnaces and two pot furnaces were being operated, turning out all kinds and descriptions of green, flint and amber bottles. At this time the works required little electrical power other than that necessary for driving blowers to cool the men operating the tank furnaces, and some steam was necessary for the pressure producers supplying gas to the furnaces and for driving a few air compressors. Everything in the way of unloading materials, mixing and distributing of the glass batch, handling coal and such work was done by hand labor.

Early in 1910 the company decided to install automatic machines and to eventually change over the entire plant to this method of manufacture. As then devised the plans for the future plant contemplated the concentration of all furnaces and machines in one building. Eleven furnaces and 28 automatic machines were to be installed. Nine of the furnaces have already been completed, and 24 of the automatic machines have been installed and are in operation. The plans also included a mechanical plant for storing, mixing and conveying the glass batch and for conveying and distributing coal to the different producers.

The new plant is driven electrically throughout. Considerable power is required to operate the automatic machines and the mechanism auxiliary thereto, such as vacuum pumps, air compressors and blowers. Motors drive the automatic machines and the revolving pots from which they gather their glass. The annealing ovens, or lehrs, of which there is one for each machine, are also motor-driven, and cars driven by motors are used to convey the coal and the glass batch. Over the same tracks 250 tons of coal are handled per day. The positive-pressure blowers for each automatic machine deliver 10,000 cu.ft. of air per min. at an average pressure of 12 oz. It is evident, then, that a great deal of electrical power is required, and to supply it the company has installed a suction gas-power plant, which is located adjacent to and centrally with the main furnace building.

Generating Units and Suction Producers

As a beginning two three-cylinder vertical gas engines with cylinders 16½x16 in. were installed. Each of these drives directly a 125-kv.-a. three-phase generator and by belt an air compressor having a capacity of 600 cu.ft. per min. Shortly afterward, two 250-hp. three-cylinder engines of the same type were installed with a 400-kv.-a.

FIG. 1. ENGINE ROOM AT ILLINOIS GLASS CO.

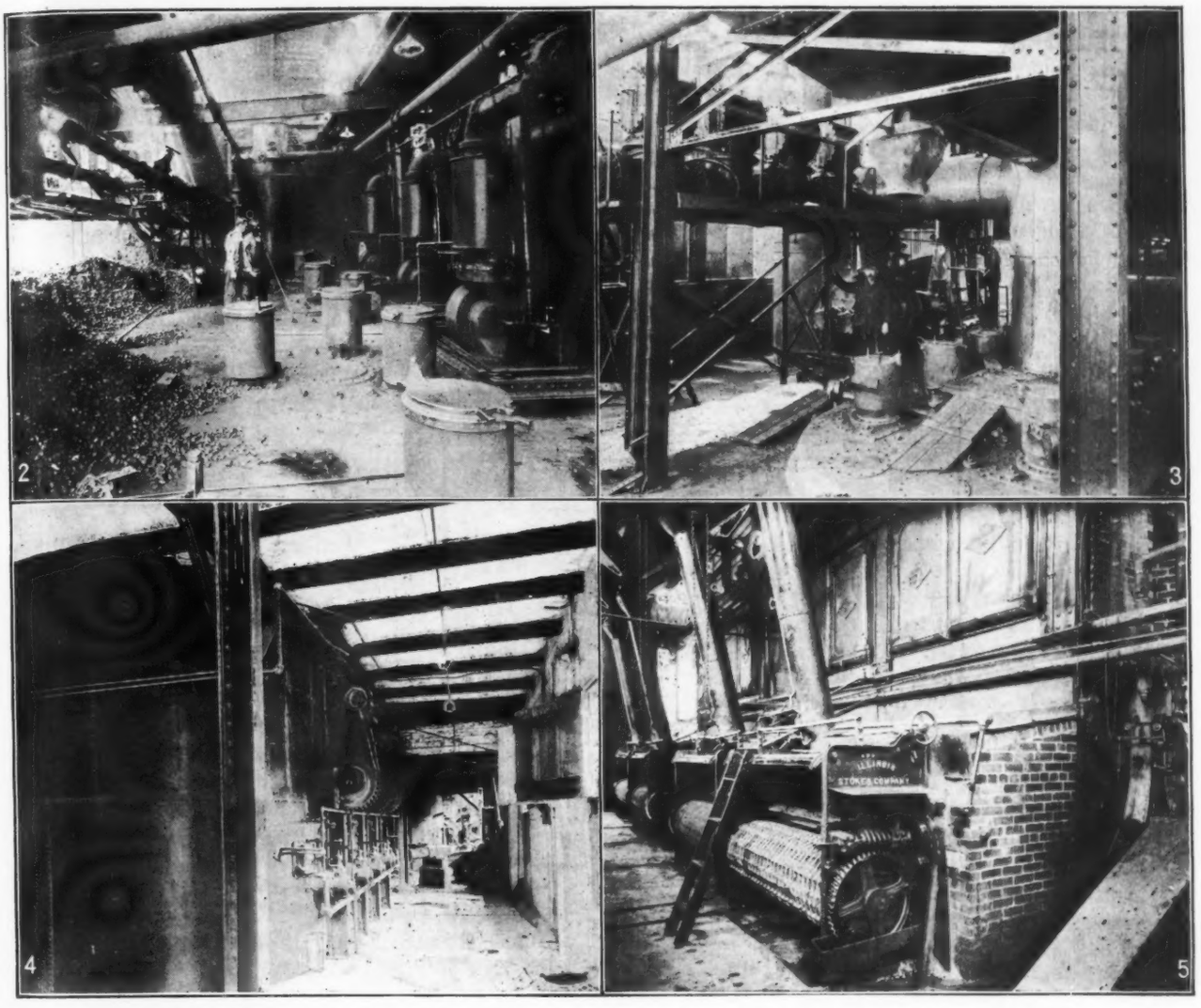

FIG. 2. PRODUCER CHARGING PLATFORM
FIG. 4. BASE OF 3000-HP. PRODUCER

FIG. 3. TAR-REMOVING FILTERS
FIG. 5. BOILERS WITH TAR BURNERS AND STOKERS

generator mounted between them, the couplings being so arranged that either one or both engines might be used to drive the generator. These machines, which are shown in Fig. 1, operate in parallel and have given excellent results.

Equipment is provided for starting the engines by compressed air. The hot water from the jackets is passed along to the saturator, which adds the proper degree of moisture to the air entering the producers. Originally, primary feed-water heaters were installed in the exhaust pipes to conserve the heat going to waste. Because of the sulphuric acid in the gases, however, these heaters proved troublesome and were finally abandoned.

To supply the engines with gas four suction producers were installed. On the basis of 1 lb. of coal per hp.-hr., two of the producers have a capacity of 200 hp. each and two are rated at 300 hp. each, although any one can carry an overload of 25 per cent. The smaller ones are 90 in. in diameter and have 24 sq.ft. of grate surface each, while the larger ones have shells 108 in. in diameter and 42 sq.ft. of grate surface. The layout of the plant is shown in Fig. 6. In the same building steam-using machinery, such as five air compressors and one large Corliss-engine-driven vacuum pump, has been retained. These units were formerly used with the semi-automatic machines employed at an earlier date and some of them are still in use.

When first installed each producer was equipped with a rotary mechanical scrubber driven by two 10-hp. motors. When maintained in good operating condition these scrubbers cleansed the gas to a degree of 3 mg. of tar and lampblack per cubic foot. Although gas of this quality was suitable for gas-engine operation, there was not a sufficient factor of safety. If any little thing went wrong with the equipment the tar content in the gas increased above the limit of 3 mg. per cu.ft. and trouble was experienced.

Spun-Glass Tar-Removing Filters

A few experiences with gas containing too much tar led to the adoption of a new type of filter consisting of a disk containing 4 oz. of compressed high-grade spun glass arranged in a reversible T-head connected to the gas line. Six of these filters are employed in order that some of them may be cut out of service for cleaning when necessary. With high-volatile coals such as are found in Ohio, Indiana and Illinois, these filters are very effective. In the present case they reduce the tar to 0.1 mg. per cu.ft. of gas. This small percentage is hardly sufficient

to discolor a filter paper left in the line for eight hours. When ordinary care is used in cleaning and replacing the filters, no trouble is experienced from tar in the engines.

It appears that the velocity of the gas through the porous disk, or diaphragm, has a great deal to do with the efficiency of the filter. On the entrance side the tar exists in a large number of minute particles ordinarily known as tar fog. In passing through the disk these particles agglomerate and form large drops, which are easily removed by passing the gas through an ordinary oil separator. It is supposed that the tar particles are precipitated by being brought into direct collision with the fibers of the diaphragm. In addition the electrical action set up by the friction of the gas passing through the diaphragm apparently increases the effectiveness of the filter. A more detailed description of this apparatus appeared in *Power* of Dec. 9, 1913.

Either of two exhausters, one having a displacement of 5 and the other 3.6 cu.ft. per min., draws the gas from the producers and forces it at 3 lb. pressure through the filters. The exhausters are driven by small vertical engines controlled by diaphragm governors that automatically maintain the desired pressure in the gas line at the filters. After passing through the filters and oil separator, the gas passes on to a vertical cooling tower made up of a series of baffle plates and provided with a spray of cool water that reduces the gas temperature to 160 deg. and precipitates a small portion of the tar. If desired the cooling tower may be bypassed. The gas is drawn directly to the cylinders of the engines by their own suction.

The tar from the filters is drained into tanks in the basement, from which it is forced into a 6000-gal. storage tank by compressed air. The pipe line is covered, and a steam line adjacent to it keeps the tar from becoming too viscous. Steam coils in the large storage tank keep the tar at a temperature at which it will flow readily to the burners under the boilers of the steam plant. With a burner on either side of the furnace, a considerable quantity of tar is burned over the coal on a chain-grate stoker. The heat value of the tar is about 14,000 B.t.u. per lb., so that it effects a large saving in coal. From the eight tons of coal used in the gas-power plant and the 27 tons in the industrial plant, about 200 gal. of tar is recovered per day of 24 hr. This is burned in the same way as fuel oil, a simple burner with a steam jet to atomize the feed being used.

An excellent quality of Franklin County coal is used in the producers. Average samples have analyzed as follows: Moisture, 7.45 per cent.; volatile, 29.64 per cent.; fixed carbon, 52.96 per cent.; ash, 9.95 per cent.; sulphur, 1.12 per cent.; B.t.u., 12,100.

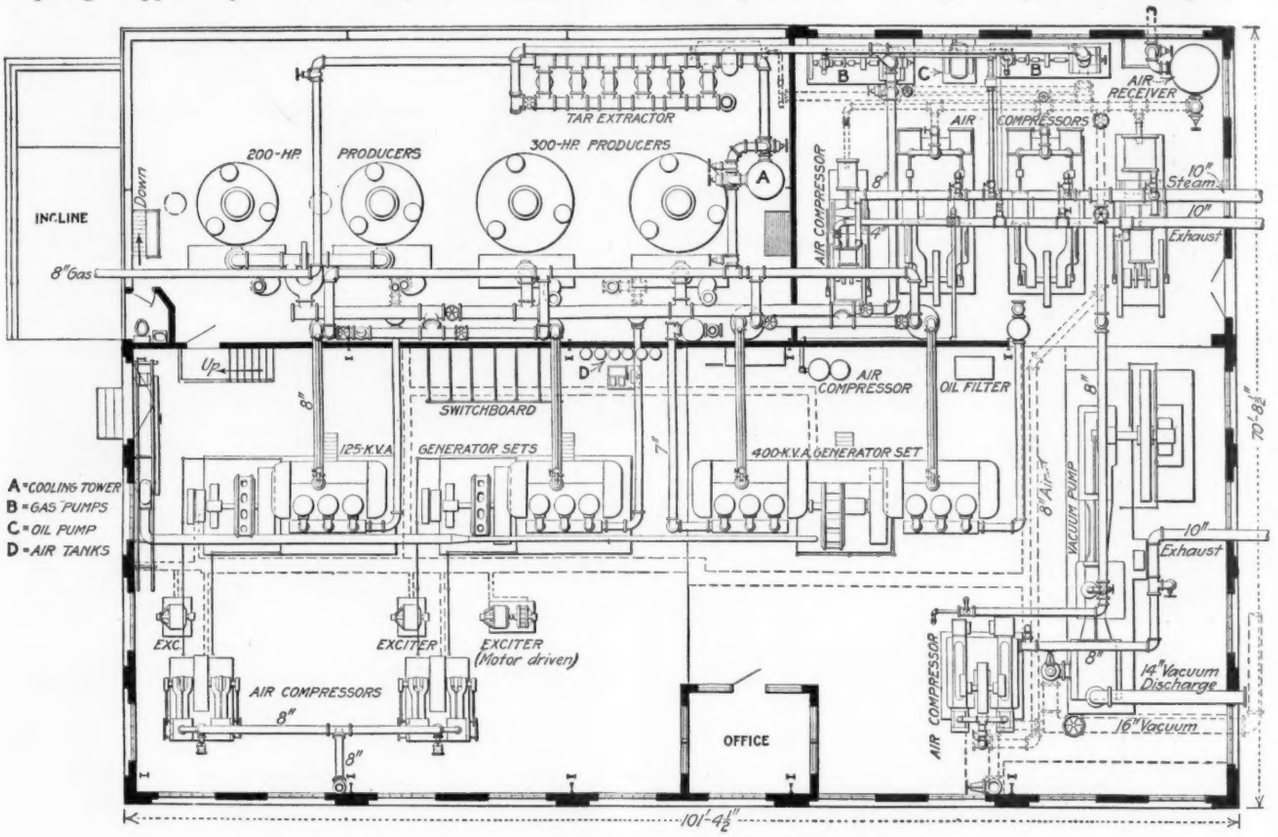

FIG. 6. PLAN OF POWER PLANT, SHOWING PIPING

The coal mentioned was from the Zeigler mines, and occasionally Big Muddy coal from Murphysboro No. 2 mine, size 1½x2 in. of the following analysis has been used: Moisture, 4.35 per cent.; volatile, 32.2 per cent.; fixed carbon, 58.6 per cent.; ash, 3.8 per cent.; sulphur, 1.05 per cent.; B.t.u., 12,200.

Either of these fuels makes good gas coal, and one of them or its equivalent must be used in the producers to obtain the best results. Coals containing more ash, moisture or sulphur clinker badly in the generators and require an excessive amount of steam to keep the fires clean. The average heat content of the gas is 150 B.t.u. per cu.ft., although at times richer gas has been made when the generators were operating at their highest efficiency and the exact degree of air saturation was obtained.

At the power plant the coal is unloaded directly from railway cars onto the firing platform of the producers and, as shown in Fig. 2, is fed into the magazines by hand. In any event the same number of producermen would have been required so that it was not thought advisable to provide coal-handling apparatus. Air for each producer is taken in through a saturator made up of a vertical tank filled with granite boulders. Hot water under control is fed into this device so that the proper degree of saturation may be obtained.

Suction Gas Producer of 3000-Hp.

In case of necessity piping connections have been made from the engines to the large suction gas producer supplying the annealing ovens. It is equipped with spun-glass filters so that the gas is clean enough for the engines. Although this producer has been given some mention in the technical press, a brief summary of its principal features may be of interest, particularly as it is stated to be the largest producer in the world. It is maintained in service 24 hr. daily, and in this period has a capacity to gasify about 36 tons of coal of the same quality used in the power plant. As with the power-plant producers, the heat content in the gas averages about 150 B.t.u., and from 6 to 8 gal. of tar per ton of coal is removed by the tar extractors.

Two views of this producer are shown in Figs. 3 and 4. It is built up of five sections, the two end ones being semicircular, while the middle ones are of rectangular cross-section. Each section is practically independent of the others, and the size or capacity of the producer is limited only by the number of middle sections which may be added. Charging is done through two hoppers in each section, located on opposite sides. The grate surface is made up of a flat rocking grate with stoking grates rising at an angle of 45 deg. on either side. The inclined grates that feed the fuel from the magazines into the combustion zone are operated by the eccentrics and ratchet arrangement shown in Fig. 4. The flat rocking grate is actuated by an air cylinder under the control of the producer attendant. This cuts the ashes out of the center of the fire. Each section has an independent cylinder and may be operated independently of the others, so that in reality the present installation is five producers combined into one with a single casing. It is more efficient than five single units would be, as some of the radiation and other losses are avoided. As will be apparent from Fig. 3 the gas outlet is centrally located. The gas passes through a preliminary cooler provided with water sprays into a positive exhauster and is forced through the tar extractors into the main.

Ashes and cinders are removed by a special vacuum ash conveyor which also serves the pressure producers operated in connection with the furnaces. The equipment consists of a 100-ton tank, a 6000-cu.ft. positive exhauster which maintains a vacuum equivalent to 1½ lb. per sq.in., and a long run of 10-in. cast-iron pipe provided with hoppers for the admission of the cinders. The exhauster is driven by a 100-hp. motor although it requires a maximum of about 65 hp., and the conveyor has a capacity to handle 50 tons of ashes in eight hours. When this system was first installed it was thought that it would be necessary to dry the ashes coming from the wet-seal producers, but in this condition they could not be handled with any degree of satisfaction. Adding more water instead of removing what the ashes already contained proved to be the solution of the difficulties. The ash and cinders are now conveyed to the tank with no trouble and are chuted directly to railway cars underneath.

Equipment of New Boiler Plant

As it was decided to retain the steam-driven air compressors and vacuum pumps previously mentioned, and as the pressure producers would require considerable steam, a new boiler plant was erected. This contains four 285-hp. water-tube boilers, set two in a battery; see Fig. 5. They are equipped with chain-grate stokers having a surface of 63 sq.ft. and, as previously stated, provision has been made to burn the tar extracted from the producer gas. The operating pressure is 140 lb. Steam-flow meters, damper regulators and a CO_2 recorder are provided and are of great assistance in operating the plant at high efficiency. Coal for the furnaces is shoveled from cars into a hopper, from which it is conveyed and elevated by a 24x18-in. bucket carrier to four overhead steel bunkers lined with concrete and having a capacity of 20 tons each. From these bunkers it is spouted by gravity into the stokers. Ashes are discharged from a pit under the stokers to the carrier previously mentioned and conveyed to two large overhead steel bunkers from which they are delivered into cars on the railway siding.

The feed-water heater is home-made from the ¼-in. steel shells of the old tubular boilers that were replaced. It is 5 ft. in diameter, 40 ft. high and contains a series of perforated baffle plates spaced on about 30-in. centers. The bottom of the heater is arranged as a filter and reservoir with a capacity of 750 gal., from which water is pumped to the boiler. Cold water enters at the top of this heater and trickles down over the baffle plates, while the exhaust steam enters at the bottom and passes up through the baffles. The exhaust comes from the steam-driven machinery in the power plant and from the feed-water pumps and stoker engine. The heater furnishes about 2000 gal. of water per hr. at a temperature of 210 deg. F. A large percentage of the solids in the water is collected on the baffle plates or settles to the bottom of the heater and is periodically removed.

The stack for the power plant is made up of special radial tile filled with reinforced concrete. There are 13 others of the same type about the works. Its height is 175 ft. and the diameter at the top 9 ft. For two-thirds of the way up the stack is lined with firebrick.

Initial and Operating Costs

As one automatic machine after another was added to the new plant, the load gradually became greater than the gas-power plant could continuously care for. It became necessary, therefore, either to enlarge the plant or to take power from Keokuk. A specially low rate was offered, and a considerable portion of the power service is now purchased. The automatic machines and the blowers connected with them run 24 hr. a day, and the load is practically constant. Consequently these machines are now operated on purchased current, delivered at 2200 volts to the plant and transformed down to 440 and 220 volts. To the gas-power plant is allotted the lighting and variable load, and it may be stated that this load is indeed variable. Ordinarily it is light and considerably below the normal capacity of the gas-power plant, but by reason of many interruptions of the pur-

chased service, it is frequently forced to carry the entire load. The gas plant must then be maintained in readiness to take over on short notice the load ordinarily cared for by the service line, and as a consequence, the efficiency has been lower than would ordinarily obtain.

In Table 1 the cost of the gas-power plant equipment, including the air compressors driven by the generating units, is given as $60,124.54. The building cost $14,207.93. As the building houses other machinery than that belonging to the gas plant, the total $74,332.47 is slightly in excess of the requirements of the latter. For engine horsepower the initial cost reduces to $78.24 and for equipment only, to $63.29. These costs per kilowatt of generating capacity are $142.95 and $115.62, which again, are a little higher than they should be, as the air compressors detract from the capacity of the generators, which might be driven by the engine units. The total fixed charges based on the percentages given in the table are $11,264.39.

Under test conditions with the fuel previously mentioned the plant has developed a kilowatt-hour on one pound of coal. Under conditions existing in the plant before service was taken from Keokuk, 3.4 lb. per kw.-hr. were actually required. The load factor, however, averaged only 40 per cent., and each air compressor belt-driven from the engine required constantly about 50 hp. which did not show up in the total kilowatt-hours.

The average operating cost per day over a period of six months previous to purchased service is given in Table 2. The total operating cost per day sums up to $48.87 and for the six months, $8894.34. The total output during this period was 906,880 kw.-hr., and the cost per kilowatt-hour, 0.98c. The fixed charges based on the total of $11,264.39 given in Table 1 are 0.62c. per kw.-hr. A summation of the operating and fixed charges gives a total cost of 1.60c. per kw.-hr. This was obtained when operating at an average load factor of 40 per cent. and includes the cost of the energy required to drive the air compressors. One of these machines was operated continuously, and it is estimated that the average power required was about 50 hp. Under good operating conditions and a fair load factor, it is evident that the plant is capable of operating at a low cost per unit. There has been very little operating trouble. The men are familiar with the peculiarities of gas power and know thoroughly the requirements which insure continuous and satisfactory service.

TABLE 1. INITIAL COST OF PLANT AND FIXED CHARGES

Cost of building	$14,207.93
Cost of equipment	60,124.54
Total	$74,332.47
Engine horsepower	950
Generator capacity, 80 per cent. p.f., kw.	520
Cost of plant per engine horsepower	$78.24
Cost of equipment per engine horsepower	63.29
Cost of plant per kilowatt	142.95
Cost of equipment per kilowatt	115.62
Fixed Charges	
Interest on investment, 6 per cent.	$4,459.95
Taxes	50.00
Insurance	31.60
Depreciation of building, 5 per cent.	710.39
Depreciation of equipment, 10 per cent.	6,012.45
Total	$11,264.39

TABLE 2. AVERAGE OPERATING COST OVER A SIX-MONTH PERIOD

(Feb. 16 to Aug. 16, 1913—182 days)

Labor: 3 enginemen, 5 producermen, 1 general repair man, and handling cinders, per day	$26.16
Av. coal per day, 8½ tons of 2000 lb.	16.29
Unloading coal, 9c. per ton	.76
Oil, waste and supplies	5.66
Cost per day	$48.87
Kw.-hr. for 182 days	906,880
Operating cost per kw.-hr.	0.98c.
Fixed charges from total in Table 1, per kw-hr.	0.62c.
Total cost per kw-hr.	1.60c

PRINCIPAL EQUIPMENT OF ILLINOIS GLASS CO. PLANTS

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Producers	Suction	200-hp.	Make gas for engines	Gas 150 B.t.u. per cu.ft.	Smith Gas Power Co.
2	Producers	Suction	300-hp.	Make gas for engines	Gas 150 B.t.u. per cu.ft.	Smith Gas Power Co.
6	Filters	Spun-glass		Cleanse gas of tar	Reduce tar content to 0.1 to 0.2 mg. per cu.ft. of gas	Smith Gas Power Co.
2	Exhausters	Positive	5 cu.ft. per revolution / 3.6 cu.ft. per revolution	Force gas through filters	Driven by Troy vertical engines 150 r.p.m.	Connersville Blower Co.
2	Engines	3-cyl. vertical	16½x16-in., 225 hp.	Main generating units	257 r.p.m.	Rathburn-Jones Engineering Co.
2	Generators	Three-phase, 60-cycle	125 kv.-a.	Main generating units	Driven by 225 hp. engines at 257 r.p.m.	General Electric Co.
2	Air compressors	Single-stage	16x10-in.	Air for automatic machines	Belted to generating units	The American Well Works
2	Generators	Direct-current	9½-kw.	Excite main units	Belted to generating units	General Electric Co.
2	Engines	3-cyl. vertical	17½x17-in., 250-hp.	Main generating unit	Both coupled to one generator	Rathburn-Jones Engineering Co.
1	Generator	Three-phase, 60-cycle	400-kv.-a.	Main generating unit	Driven by two 250-hp. engines, 257 r.p.m.	General Electric Co.
1	Generator	Direct-current	14-kw.	Excite 400-kv.-a generator	Driven by motor at 1200 r.p.m.	General Electric Co.
1	Producer	Suction	3000-hp.	Gas for annealing ovens	Gas 150 B.t.u. per cu.ft.	Smith Gas Power Co.
1	Exhauster	Positive	16½ cu.ft. per rev., 220 r.p.m.	Force gas through filters	Driven by 13x13 in. Shepherd vertical engine	Connersville Blower Co.
4	Filters	Spun-glass		Cleanse gas of tar	Reduce tar content to 0.1 to 0.2 mg. per cu. ft. gas	Smith Gas Power Co.
4	Boilers	Water-tube	285-hp.	Steam for misc. machinery	Natural-draft stokers	Toledo Flanner Boiler Co.
4	Stokers	Chain-grate	63-sq.ft.	Serve boilers	Driven by vertical engine, 7x7 in.	Illinois Stoker Co.
1	Peck carrier	Bucket	18x24-in.	Handle coal and ashes	Driven by motor	Link-Belt Co.
1	Chimney	Tile	175 ft. high, 9 ft. diam.	Serve boilers		Wiederholdt Construction Co.

To T. C. Moorshead, assistant manager of the works, we are indebted for much of the information contained in this article. James O'Brien is chief engineer of the power plant.

Proposed Hydro-Electric Power for Seattle

Possibilities for the development of the Sauk and Suiattle River projects, so that 167,000 hp. of electrical energy may be delivered in Seattle, the development cost to approximate $16,000,000, were recently pointed out by City Engineer Dimock in a letter to the City Council of Seattle. The report on the proposed development was prepared by Robert Howes, consulting engineer, and accompanied Mr. Dimock's letter. The city has a priority on the Sauk and Suiattle power sites, but it is against the policy of the Government to allow a corporation or person to hold a power site without engaging in active operations; therefore immediate action is necessary by the city in carrying on further investigations. Mr. Howes reports as a result of his preliminary investigation that an initial installation of 44,000 hp. is possible at a cost of $4,300,000. The projects for the most part lie within the national forest reserves, and Seattle may take advantage of the Government forest reserve regulations enabling cities to acquire power sites for municipal purposes at a nominal cost.

The location of the proposed development is in the vicinity of Darrington, and the length of the transmission line will be about 75 mi. The initial installation would include a small diversion dam on the Suiattle River. The water would be carried by means of an open conduit and a tunnel to a point on the mountainside near the town of Darrington, from which point penstocks would lead to the power house.

Havana Consolidated Power Plant--II

By C. W. Ricker*

SYNOPSIS—Condensing water is taken from, and discharged to, the harbor through a concrete canal built with a dividing wall to separate the intake and discharge water. The canal is under the turbine foundations and the circulating pumps are just above the canal. Exhaust steam from the auxiliary turbines goes to a feed-water heater, but when more steam is supplied to the heater than can be condensed, the excess steam can flow to the low-pressure stage of the main turbines. The piping system is of interest and placing double handwheels on the most important valves, separated by a wall or floor, assures safe control of the boilers and the high-pressure system.

Extending the length of the building and 80 ft. south of and directly under the turbine foundation, a canal with concrete walls and bottom fully supported on piles is built for the condenser circulating water that is drawn from and returned to the harbor. A central partition wall divides the entering water from the discharge, and the concrete piers that form the turbine foundation rise from the side walls of this canal and are further stiffened by reinforced-concrete cross-beams. The top of the canal is covered with a 9-in. reinforced-concrete slab on which the circulating pumps are set, directly over the center wall. The piers supporting the generating units are tied together longitudinally by deep reinforced-concrete beams and crosswise by steel girders that support the turbine generators and condensers. The condensers are accessible all around and may be removed endwise after dismounting the circulating pump, or upward by shifting the turbine.

Directly below each main turbine and between the piers supporting the unit is placed a 30,000-sq.ft. surface condenser with the circulating pump at one end and the air and hotwell pumps at the side, all on the ground floor. All of the principal turbine auxiliaries are set along a wide aisle running the length of the basement on the side nearest the boilers, the boiler-feed pumps and the heater and the plant-service pumps being in the single space between the second and third turbine foundation, opposite the exciters on the floor above.

The relative positions of the turbine condensers and circulating-water canal reduce both the exhaust-steam travel and cooling-water piping to the minimum. One 42-in. pipe is used for the circulating-pump suction and two 28-in. pipes for the overflow from each condenser. The suction pipe passes directly through the top of the canal into the intake side and the two discharge pipes from each condenser into the discharge side of the canal.

At a point just beyond the 80-ft. extension limit south of the building, the canal divides into two lines of cylindrical reinforced-concrete pipe, one of which connects the discharge canal to the harbor at the downstream end of the wharf and the other runs parallel to the end of the building to a screen basin built for the old plant, which in turn is connected to the harbor by a tunnel 5 ft. square. In this basin are four baskets made of copper frames covered with heavy wire screens and so arranged that flat screens may be dropped in front of them and the baskets removed one at a time, carrying the material that they have strained out of the water. Any matter that lodges against the flat screen is washed into the bucket when it is replaced, and the flat screen is removed. The screens are lifted with a chain block. This will later be replaced by a compressed-air hoist. The material removed consists largely of jellyfish that clog the screens of the condenser tubes if not removed.

The old connections in the harbor are large enough for the present needs, but when the growth of the load requires, an 84-in. pipe line will be added, taking water from a point farther upstream.

Over the water level in the discharge canal and just below the cover is placed a 30-in. cast-iron water line, which connects the inlet chamber of the three condensers, so that if necessary a circulating pump can supply a limited amount of cooling water to any of the condensers.

The water boxes, covers and circulating piping of each condenser are so divided that the circulating water can be cut out from one half for cleaning, leaving the other half in service with a loss of only one or two inches of vacuum during the process. This rather unusual arrangement was made because at times the harbor water has in suspension a large amount of sticky matter that coats the condenser tubes and reduces their transmitting capacity seriously. It is, however, easily washed out with a brush and a small stream of water. The condensers slope about eight inches from horizontal, so that the tubes may drain empty when not in use. This diminishes corrosion, which is unusually severe because of the high temperature and impurities in the salt water used for cooling.

Details of Feed-Water Heaters

The exhaust steam from all the turbine-driven auxiliaries passes into a header running the length of the turbine-room basement about 11 ft. below the floor. At the center, connections are made to two 300,000-lb. per hr. capacity boiler-feed-water heaters and at suitable points to inlet valves to the low-pressure stage of each of the main turbines. This admits steam at constant pressure, so that when more steam flows into the exhaust header than can be condensed in the feed-water heaters these valves open and the excess flows into the main turbine and does useful work. It is estimated that under normal conditions one pound of this exhaust saves from $\frac{3}{10}$ to $\frac{4}{10}$ lb. of high-pressure boiler steam and, being then condensed, becomes available for boiler feed instead of exhausting to the air.

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The exhaust header is also provided with outlets to the atmosphere through back-pressure automatic release valves set to open at slightly higher pressure than needed to lift the constant-pressure valves to the main turbine, so that there is no danger of excessive pressure in the exhaust line even if the inlets to the main turbine should be closed.

In order to allow the escape of the air and other gases present in the steam, the feed-water heaters are provided with vent pipes that connect to a small surface condenser, through which the cold water passes on its way to the main heaters. Each heater thus discharges through a vent a mixture of air and steam; the latter is condensed and the air escapes through suitable openings. Owing to the arrangement of outlet valves of the exhaust system the heaters are always under a slight pressure and therefore no pumps are needed to draw the mixture of air and steam through the vents.

The condensed steam from the main turbine is drawn from the large surface condenser by the hotwell pumps and sent through the condensate heater into a V-notch meter of 400,000 lb. per hr. capacity. It is located on the turbine-room floor, and a continuous record is made of the amount of water passing. The water flows from the meter into a pipe under the boiler-room floor. This pipe is connected to the water inlet of the feed-water heaters and to two large tanks in the boiler room, each having a capacity of about 100,000 lb. of water. One of the tanks is also supplied with cold water, both from the plant service system and direct from the city water mains.

Because the regularity and pressure of the city water service is not reliable enough, a plant water-service system has been provided, consisting of storage tanks and pumps. This system will be described further on. Under normal conditions, the condensate is admitted to only one of the boiler-room tanks and the other is kept full of city water. A float in the first tank controls a valve in the line from the second to the water inlets of the feed-water heaters, so that whenever the condensate is not sufficient for the boilers, makeup water is automatically admitted into the heaters from the city water tank.

The temperature of the water inside the heaters is raised to about 210 deg. F. It then flows through two V-notch feed-water meters similar to that on the turbine floor, so that a complete record may be kept of the total water fed to the boilers, consisting of that returned from the condensers, that returned from the traps which discharge into the heaters, and the city water needed to

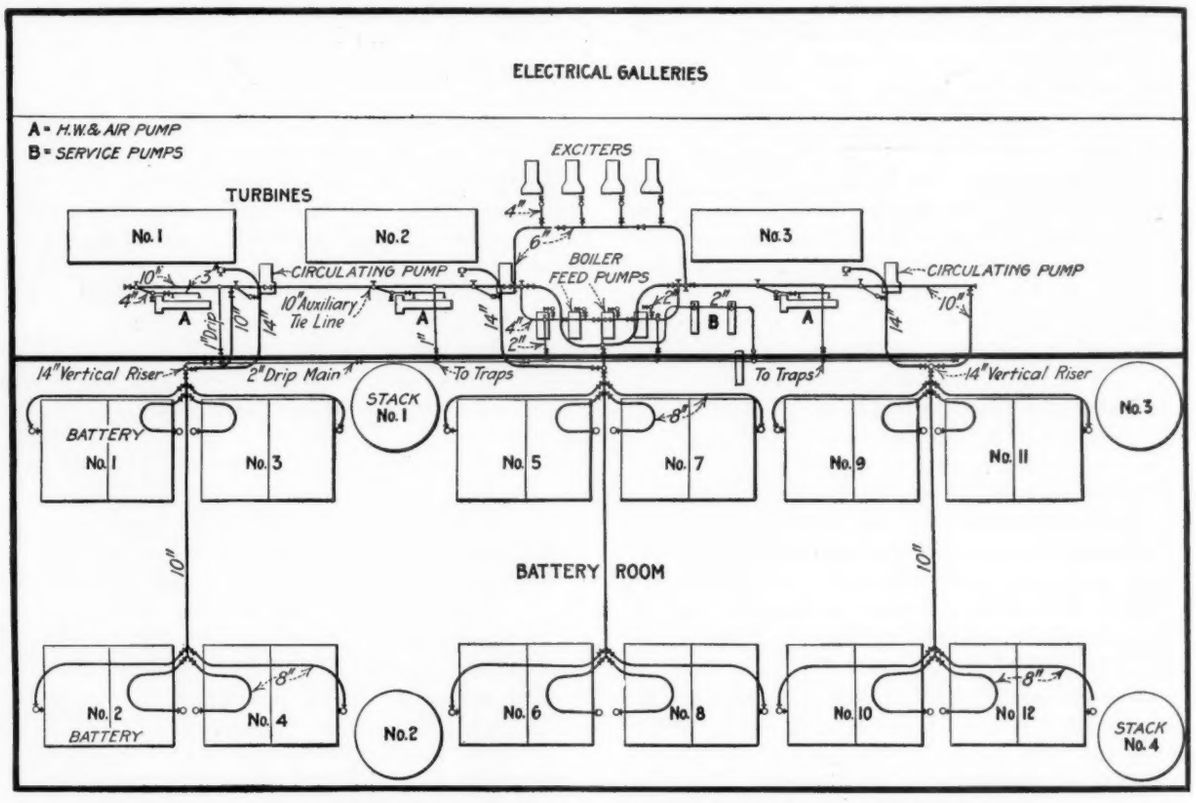

FIG. 10. HIGH-PRESSURE STEAM DIAGRAM OF THE MAIN AND AUXILIARY LINES

complete the amount required for boiler feed. This hot water flows from the V-notch feed meters to the boiler-feed pumps.

The supply lines from the heaters to the boiler-feed pumps are arranged so that water may be drawn from both heaters at once by all of the pumps, or two can draw from one heater while the other two draw from the other heater independently. The suction header of the boiler-feed pumps is connected directly to the plant water-service system, so these may receive cool water or condensate from the elevated tanks forming a part thereof or directly from the service tanks, also from the city water main, so that in an extreme emergency city water can be pumped directly into the boilers. The subdivision of this header by valves permits two of the boiler-feed pumps to receive cold water, while the other two receive water from the heaters. The delivery header is divided like the suction header, leaving the pumps in

two pairs, and the feed piping is in duplicate to the boiler connection cross-headers, each of which supplies four boilers. This constitutes a loop system fed at the middle, either side of which is adequate for full service. The whole is sectionalized, so that any group of four contiguous boilers can be separated from all the others in use and fed from separate pumps, heater and water-meter for the purpose of trial or observation.

The three 400-gal. per min. plant-service pumps draw water from the storage tank outside and deliver it to the service-water header. The latter is connected to a 3000-gal. tank on the roof of the boiler house, to the feed-water tank on the boiler-room floor, to the water-inlet pipes of the heater, to the supply line of the boiler steam pumps, to the various water-cooling connections of the main and exciter turbine, to the transformers, and to the sanitary service. The water used in cooling the oil in the turbines and transformers is returned through an outside storage tank.

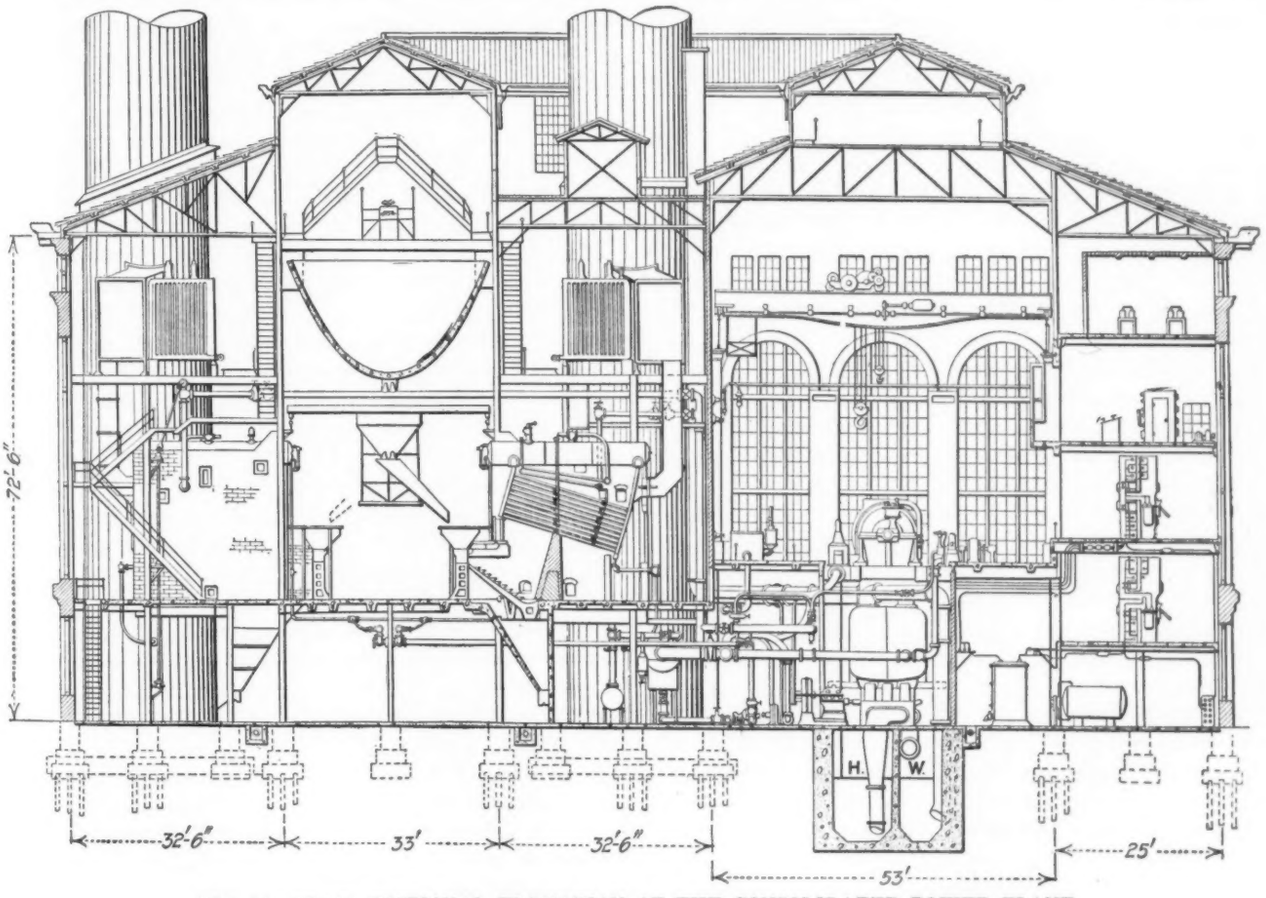

FIG. 11. CROSS-SECTIONAL ELEVATION OF THE CONSOLIDATED POWER PLANT

Details of Piping Arrangement

As already stated, boilers are arranged in groups of eight, each consisting of four batteries, two on each side of the boiler-room main aisle. Each lead of the four boilers of a group each side of the aisle is connected through horizontal bent pipes into a special horizontal double Y-fitting having a 10-in. end opening. These two Y's are each connected by a horizontal 10-in. pipe to a vertical 14-in. header, which extends down into the basement close to the middle wall.

Just below the turbine-room floor a 14-in. horizontal bend connects to the corresponding main turbine, and just below the boiler-room floor a 10-in. horizontal bend connects to the 10-in. equalizer, or tie line, between the three 14-in. group headers. Below the latter outlet the header continues as a drip leg, with a drain connection to a group of steam traps. This drain is in turn connected to a general drainage header.

To supply the various steam-driven general station auxiliaries there are two loop headers, one for the exciters and one for the pumps, both connected to the 10-in. equalizer on both sides of the middle boiler header and both provided with valves. Thus the exciters, boiler-feed pumps and house-service pumps can be fed from whichever section of the boiler plant is in service, leaving the remaining boiler group headers and other two sections of the equalizer header cold. The auxiliaries of each generating unit, comprising the condenser pumps, oil and gland pump, are connected directly to the equalizer, or tie line, just opposite the main turbine.

With the arrangement of piping outlined, Fig. 10, it is possible to operate any main generating unit with a full complement of auxiliaries from any of the boilers, although of course there would be considerable drop in pressure under extreme conditions. Full load can be carried on one turbine when supplied through the natural length of steam piping, and a large saving in costs of piping is effected by the use of a small tie line instead of a connecting header system.

The steam tie-line header, the exhaust-steam header, the condensing header, the feed pumps and the feed-pump headers, the principal service-water line, the drainage lines of the steam pipes and, as far as possible, all other general piping are located beneath the turbine room

along the aisle by the auxiliaries, in plain sight and within easy reach. There are galleries under the more important lines for ready access to the valves. The boiler-feed water distributing lines are similarly located beneath the boiler-room floor in the aisle between the ash hoppers.

Important Valves Have Double Handwheels

To assure the safe control of the boilers and the high-pressure steam system in case of a rupture at any point, the most important valves have two sets of operating wheels, separated by a building wall or floor. Each boiler has an automatic angle-type, nonreturn valve close to the superheater nozzle in addition to the cutoff gate valves. This angle valve may be closed with a handwheel on the valve stem, which is also geared to a vertical spindle running down beside the boiler into the basement, with handwheels within reach of the boiler- and basement-room floors respectively. The valves in the 10-in. line between the double Y's, which gather up each half-group of four boilers and a 14-in. vertical group header, have handwheels on the valve stems and bevel-gear extension to the middle wall, with handwheels in the turbine room which may be reached from the crane carriage or from ladders. The 14-in. gate valves in the leads to the main turbine close to the vertical headers also have handwheels on both sides of the middle wall, and the 10-in. valves in the connection between the vertical group headers and the 10-in. equalizer header and the sectioning valves in the latter are opened by handwheels on floor stands above the turbine-room floor.

All high-pressure steam and boiler-feed piping is made up with rolled-steel flanges and cast-steel fittings. Steam piping 4-in. and larger has Van Stone type flanges. The more complex headers have welded branches and flanges. All pressure steam and feed valves larger than 2 in. are cast-steel, outside-stem gates with Monel-metal gates, seats and stems. Some of the more important 2-in. valves are of similar type, and all the rest are globe valves. All high-pressure steam valves 6-in. and larger are Ventura pattern.

A network of air-pressure piping and one for vacuum cleaning extends throughout the building, with frequent openings for hose connection. Suitable air compressors and exhausters are provided for the services. A cross-sectional elevation of the power plant is shown in Fig. 11.

Station Electrical Apparatus

Along the side of the main generating-unit foundations, away from the boilers, a brick wall divides the basement story from end to end, leaving full-sized openings into the spaces under the generators, each of which is closed by another wall toward the boilers, so that the east side of the basement serves as a ventilating duct, or aisle, and is completely separated from any part of the building containing steam machinery or piping. In this space the nine 2,000-kv.-a. raising transformers are set and the main generator and the exciter leads are run in the open between their respective generators and the bus and switch structures.

These are set in three groups near the main generators, with the high- and low-tension busbars of each group supported from the building structure on opposite sides of the transformers, leaving the space above clear. The primaries are connected in delta and the secondaries in Y. A neutral bus is to be run the length of the room with disconnector switches between it and the neutral lead of each group. It is proposed to build this neutral bus through a noninductive resistance as soon as the 13,200-volt feeders are put under ground.

Over all the large transformers are removable hatches in the turbine-room floor through which the crane can lift the transformers. To screen the turbine room and operating galleries from the noise as much as possible, no openings are left between the ventilating aisle and the turbine room.

The east side of the building is divided by four galleries about 26 ft. wide, on which are placed all the station busbars, switch gear and electric control apparatus (Fig. 8, first installment). This arrangement separates the electro-switching and control apparatus from the steam equipment almost as completely as if they were in separate buildings and at the same time preserves the unity of the plant and the accessibility of each class of equipment.

All power wiring and leads between the main generators, exciters, transformers, busbars, circuit breakers and cable terminals are made up of insulated and braided cable of moderate size run openly on porcelain insulators supported on iron racks or brackets.

The first of the galleries that occupy all the eastern side of the building contains the 13,200-volt busses and switches; the second is used for the 2200-volt busses and switches (Fig. 7, first installment); the third for the operating switchboard and offices, and the fourth contains only the control storage battery.

All feeders leave the building in lead-covered three-conductor cables. Both the 2200- and the 13,200-volt busbars are in duplicate and the main generator and both primary and secondary leads of the rising transformers have duplicate, relay-controlled, automatic circuit-breakers, one for each bus, to which the apparatus is connected. Only the feeder circuit-breakers are not duplicated, and they may be connected to either of their respective busses by disconnector switches arranged for use as selectors. The 2200-volt busses are continuous, and the generator and transformer circuit-breakers are spaced along them substantially opposite the apparatus they control. The 13,200-volt busses are divided into three sections, each connected to one bank of rising transformers. The sections are separated by lever-type disconnecting switches. At each end of the 13,200-volt bus is a set of electrolytic-type lightning arresters to discharge voltage surges. They were installed especially for use during the change of operation with neutral not grounded.

This particular arrangement and subdivision was chosen to permit the complete separation of the railway and heavy power from the lighting, and to this end each of the two 2000-volt generator busses is provided with a separate Tirrill regulator. Each distribution may then consist of both high- and low-tension feeders without interference with the other. It is also convenient for maintenance work which, if necessary, may be carried out during the hours when lightning conditions are less exacting.

The operating room is in the middle of the third gallery just opposite the exciters, in the space between the second and third generators. The front projects about four feet beyond the gallery edge and is inclosed with

wire-glass set in steel casement sash. The control and instrument switches and indicator lamps are mounted on an inclined desk divided into sections—one for each generator, exciter, transformer bank and group of six feeders—arranged in the same order as the apparatus. On the desk is mounted a copper-strip diagram of the station busses, and connections with the control handles, signal lamps and model disconnector switches are placed to correspond with the real circuit-breakers and switches, so that the operator has a plan of the station connections always before him.

The exciters are controlled from a switchboard with several panels standing in line with the instrument board. The exciter bus is in duplicate, so that the exciter switches and generator field switches, the latter being directly operated from the control board, are double-throw.

The station light and power service is controlled from a three-panel switchboard that stands near the bench-board at right angles to it. This switchboard controls the bank of auxiliary power transformers, the lighting transformers and various fused lighting and power circuits feeding all parts of the stations.

An electrically operated signal system will be installed for communication between the switchboard and the individual main units, with a large illuminated signal board in the turbine room, the control of which will be added to the present control desk.

The electric installation is arranged so that it can be added to without confusion and without sacrifice of any of the essential parts of the plan adopted. The bus and switch structures and the control switchboards are all groups of uniform units and may be extended by the addition of more similar units. All the wiring and cables are open and accessible, and the number of different operating voltages has been kept as low as possible. The completion of this station gives Havana a remarkably modern power plant.

The Panama-Pacific Exposition--III

By F. R. Low

SYNOPSIS—The sole steam engine piped up and ready to run is a 150-hp. single-cylinder, high-speed. The only other examples are a twin sawmill engine with balanced slide valves and a high-speed, vertical, French engine with forced lubrication. There are four Diesels, two of 500-hp., each being the largest prime movers in the Exposition, excepting the inoperative waterwheels.

Engines--Steam and Diesel

The man who at the time of the Louisiana-Purchase celebration should have ventured the prediction that the largest reciprocating steam engine at the next international exposition would be a single-cylinder, four-valve, high-speed unit of 150 hp. would have been laughed off the platform. That this is true of the Panama-Pacific Exposition does not indicate that the steam engine has chuted toward desuetude at the rate indicated by the difference between the steam-engine displays of the two expositions, any more than that the little 625-kv.-a. Westinghouse steam turbine, the largest—and only—American example exhibited, indicates the limit of American achievement with this vanquisher of the steam engine.

The primary reason for the absence of steam engines—and turbines too for that matter, not to mention boilers, condensers and all sorts of heavy power plant—is the fact that there is no use for them. The energy necessary for running and lighting the Exposition is brought into the grounds by a hidden cable. There is a service station back of Machinery Hall, but it is not an exhibit and is not intended to be visited.

Nobody who thought or was informed expected such an exhibit of large reciprocating engines as were shown at Chicago, Paris and St. Louis. Such engines are not built any more except for special purposes; but he might have looked for some demonstration of the progress which has been made in the economical use of steam. An amount of interest which would have warranted their purchase and installation as engineering demonstrations, if the manufacturers were not willing to exhibit them themselves, would have been excited by a locomobile, preferably coal-fired, but oil-fired if necessary, with continuous visible records of the fuel consumed, water evaporated, steam quality and rate and power produced, or by a representative of the uniflow type running in competition with a representative of the high-speed superheating type like the Lentz, each with flow and kilowatt meters that would show their input and output.

But exhibitors are not inclined to send heavy machinery like steam engines across the continent into a region where there is little likelihood of their finding a sale and not having to be brought back, simply to let them stand idle or run at their own expense, grinding out juice to heat a water rheostat; and people will not send heavy boilers unless they are to have a chance to justify their presence by use and to mitigate the expense of their installation by their earning capacity. The operative steam power plants have been elbowed out by purchased current, and an exposition of immovable prime movers offers no advantages to the exhibitor and little attraction to the visitor. The only operative example of a reciprocating steam engine on exhibition is here as a side show to a couple of Diesels, by even the smaller of which it is completely overshadowed. This engine is itself an exemplification of the effect of the steam turbine upon the engine-building industry. Its builder, the McIntosh & Seymour Corporation, of Auburn, N. Y., furnished for years high-grade engines, mostly in large-sized verticals, for central-station and factory work. The encroachment of the turbine upon the demand for engines of this class led the company to adapt its design to the smaller high-speed horizontal self-contained type, for which a considerable demand still persists for office-building and kindred uses. The engine exhibited (Fig. 9) has a diameter of 12 in., an 18-in. stroke, is designed to run at 235 r.p.m., or 705 ft. per min. piston speed, and to develop 150 hp. noncondensing,

with 140 lb. initial pressure. The gridiron valves are in the heads and are interchangeable.

The only other steam engine in Machinery Hall is a twin-cylinder, throttle-governed, balanced-slidevalve engine, part of the exhibit of the Sumner Iron Works, makers of sawmill machinery. In the French section of Manufacturers' Palace is a 300-hp. Delauney Belleville vertical high-speed not piped up.

Notwithstanding the entire absence of producers and the presence of gas engines in only insignificant sizes, the display of internal-combustion engines quite eclipses the meager display of steam engines. The rise and fall of the large gas engine has not been quite so precipitate as would be indicated by the first 1000 hp. Cockerill at Paris in 1900, the subsequent immense installations at Gary and elsewhere, and nothing here in 1915. I say nothing, for while some small machines are running on city gas they have carburetors and could be equally well run with liquid fuel.

The most conspicuous exhibits in the engine line are the two 500-hp. four-cylinder vertical Diesel engines, one by the Busch-Sulzer Bros. Diesel Engine Co. and the other by the McIntosh & Seymour Corporation. The Busch-Sulzer exhibit is particularly attractive and designed to impress the observer with the fact that the use of a Diesel engine is not incompatible with luxurious and delicate surroundings. The space (Fig. 10) is wainscoted and railed with the rare South American jenizero wood. White columns supporting the sign, Turkish rugs on the floor, ferns and palms, elegant furniture and attendants in spotless white uniforms are used to carry out this motive. This was one of the first exhibits ready in Machinery Hall and has played an important part in the Exposition ceremonies, being the engine which was started by President Wilson by a wireless impulse from Washington on the opening day. It is attached to a Westinghouse generator and supplies practically all of the continuous current used in and about the Exposition. This is the first machine turned

PARTICULARS OF DIESEL ENGINES AT PANAMA-PACIFIC EXPOSITION

	Busch-Sulzer	McIntosh & Seymour Type A	McIntosh & Seymour Type B	New London	Fulton
Rated horsepower (brake)	500	500	280	180	50
No. of cylinders	4	4	3	6	3
Diameter of cylinder	19	18¼	16	9	8
Stroke	24½	28¾	24	12½	9
Revolutions per minute	200	165	200	350	400
Compressor	3-stage direct	2-stage direct	2-stage direct	2-stage direct	2-stage direct
Compression pressure, lb.	500	500	500	450	500
Injection pressure	600-800	600-800	600-900	800	825-975
Weight per horsepower, lb.	375	324	322	100	100
Governs by	Control of suction	Control of stroke	Control of stroke	Control of suction	Control of bypass
Air starting	2-cylinder	1-cylinder	1-cylinder	3-cylinder	2-cylinder
Piston water-cooled	Yes	No	No	No	No
Air starting pressure, lb.	800-850	800	800	750	700-1000
Service	Stationary	Stationary	Stationary	Marine	Marine
Piston speed	816¾	780	800	875	600
M. E. P. at 75%	94.98	100.72	102.08	113.78	97.22

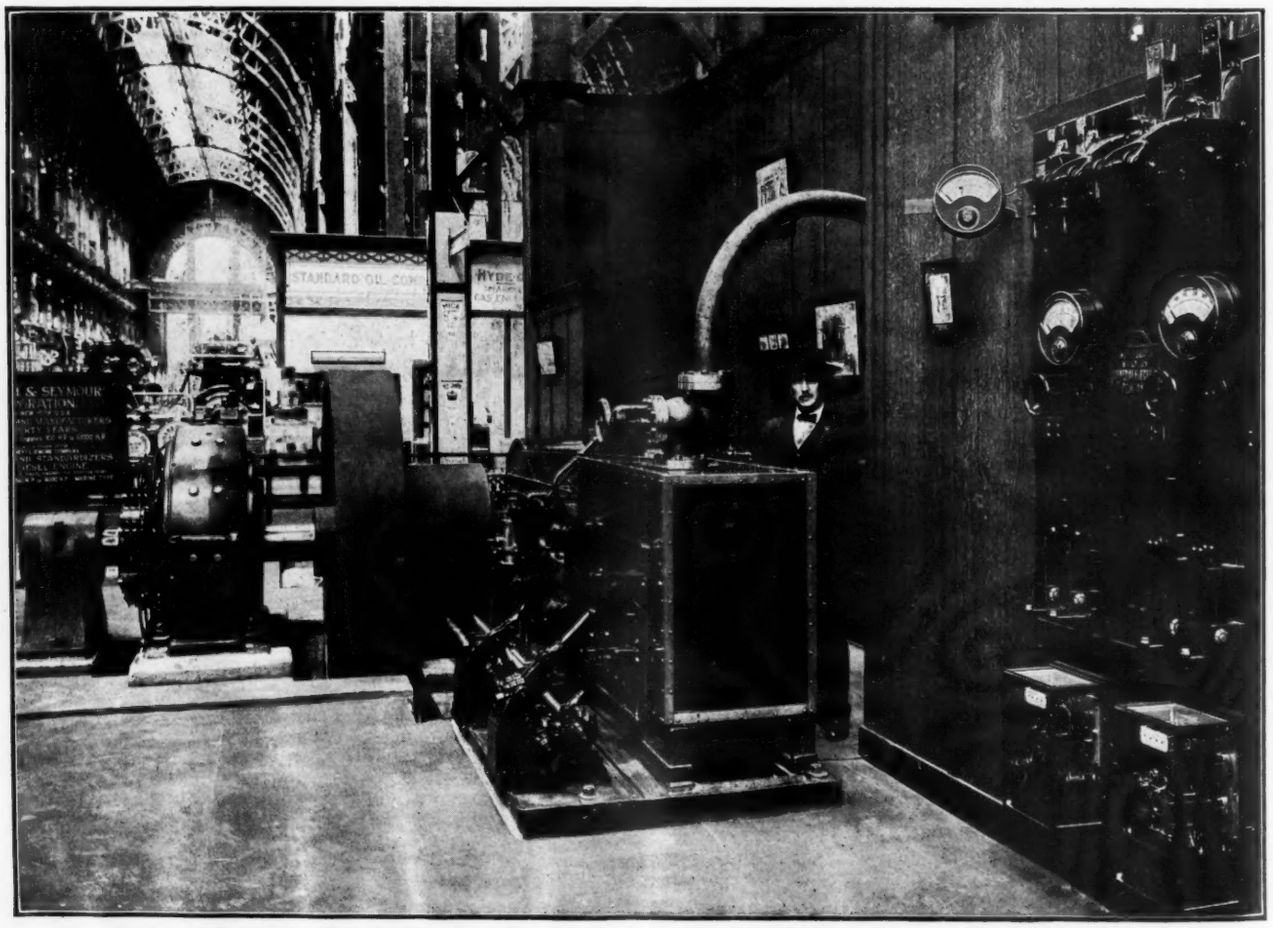

FIG. 9. THE ONLY OPERATIVE STEAM ENGINE IN THE EXPOSITION

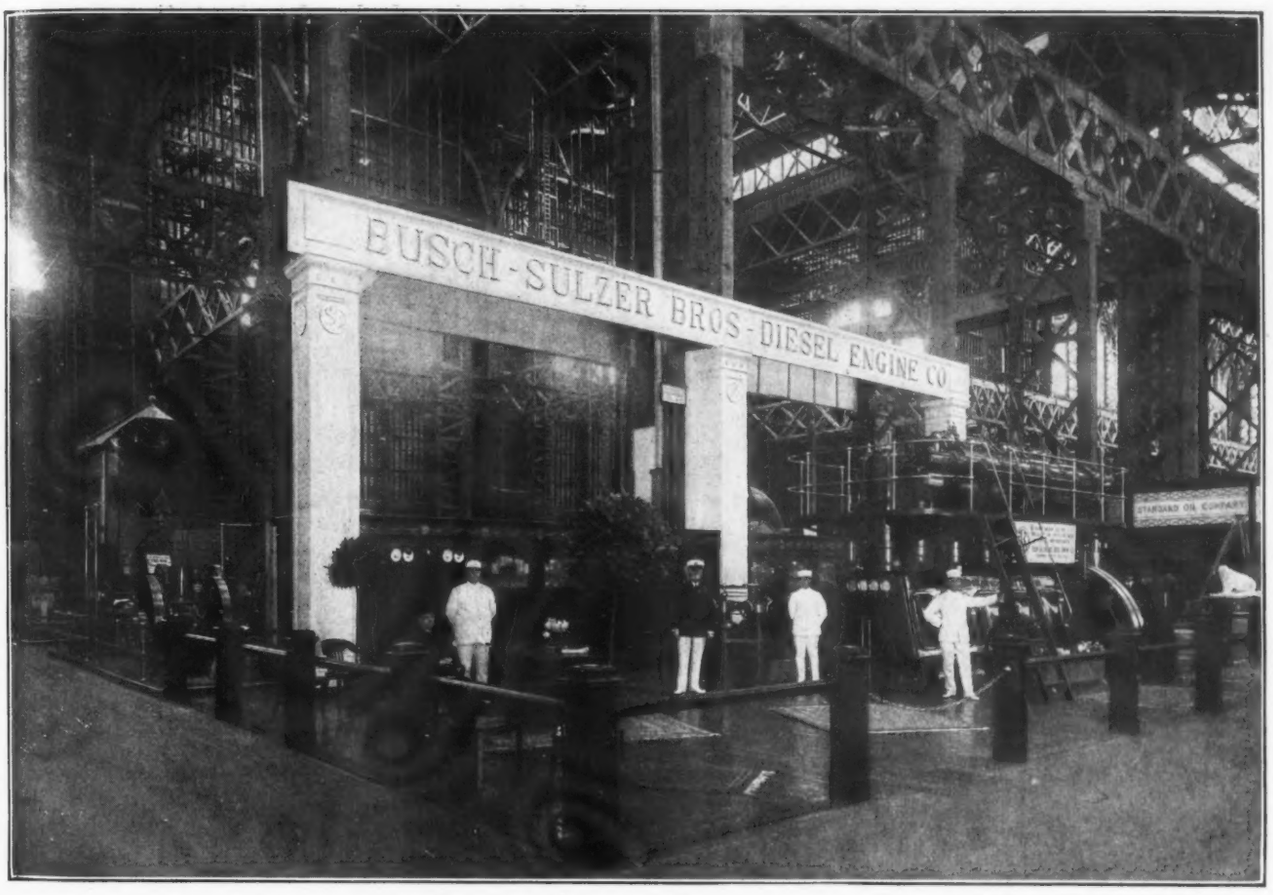

FIG. 10. EXHIBIT OF THE BUSCH-SULZER BROS. DIESEL ENGINE CO.

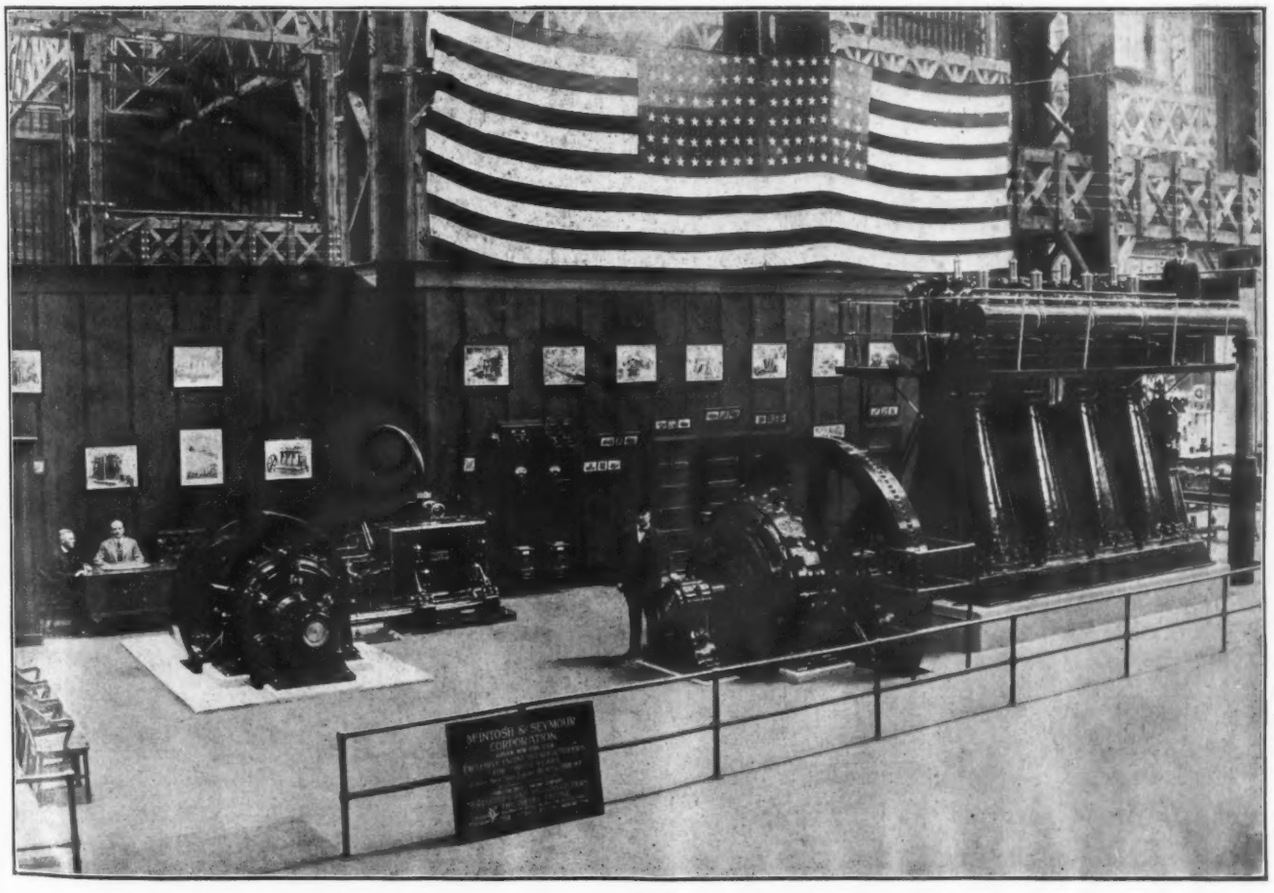

FIG. 11. EXHIBIT OF THE McINTOSH & SEYMOUR CORPORATION

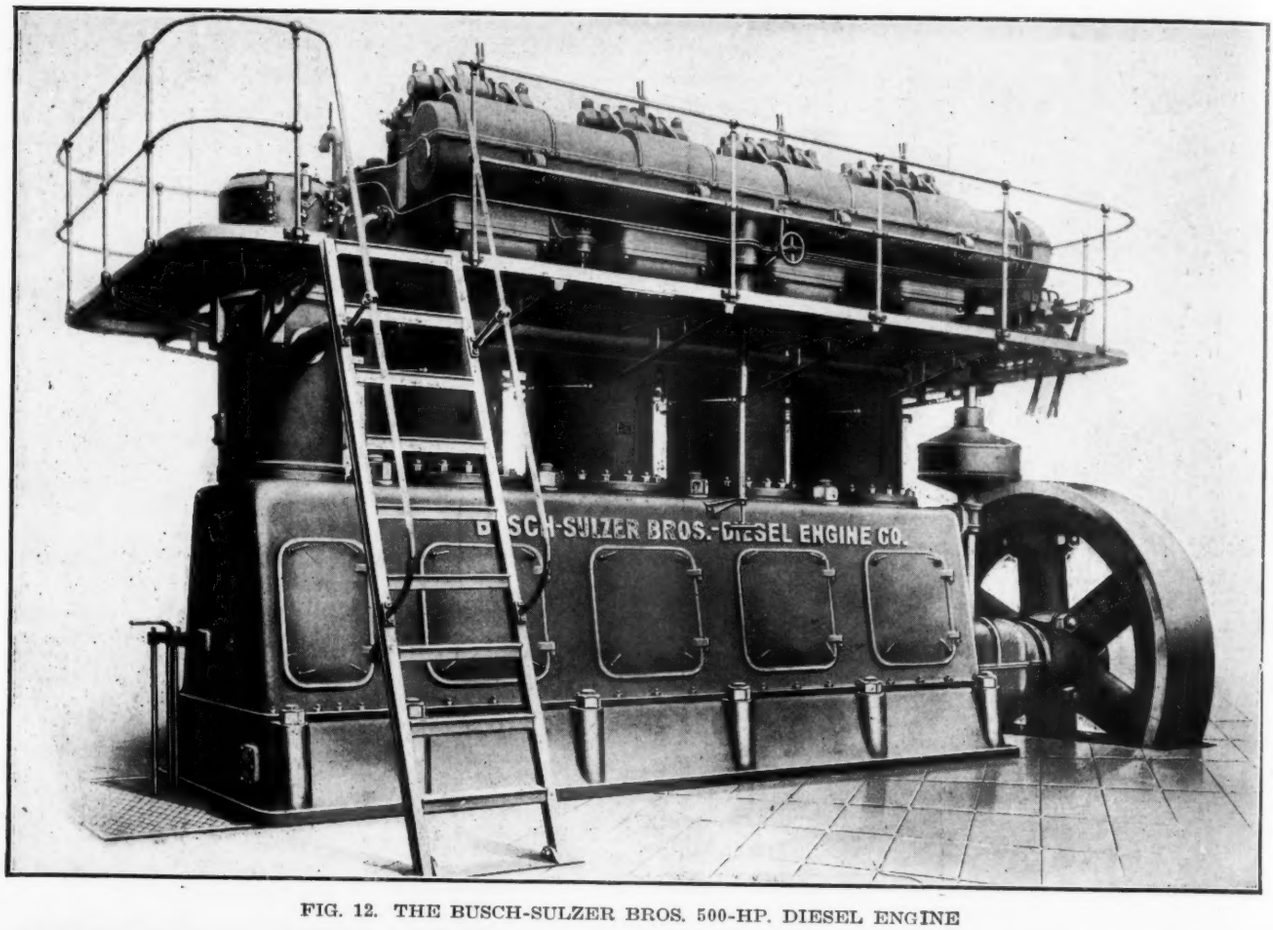

FIG. 12. THE BUSCH-SULZER BROS. 500-HP. DIESEL ENGINE

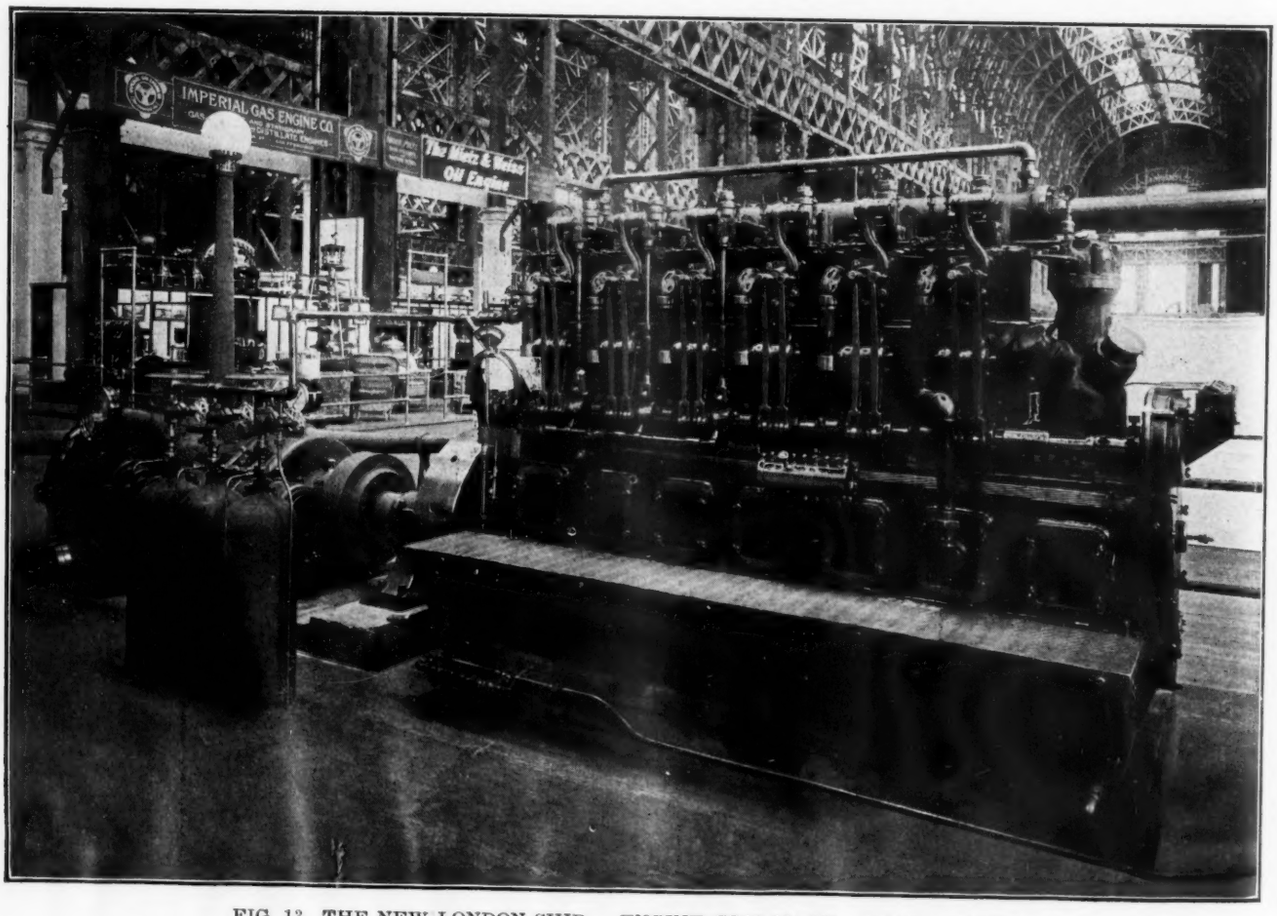

FIG. 13. THE NEW LONDON SHIP ENGINE CO.'S 180-HP. DISEL ENGINE

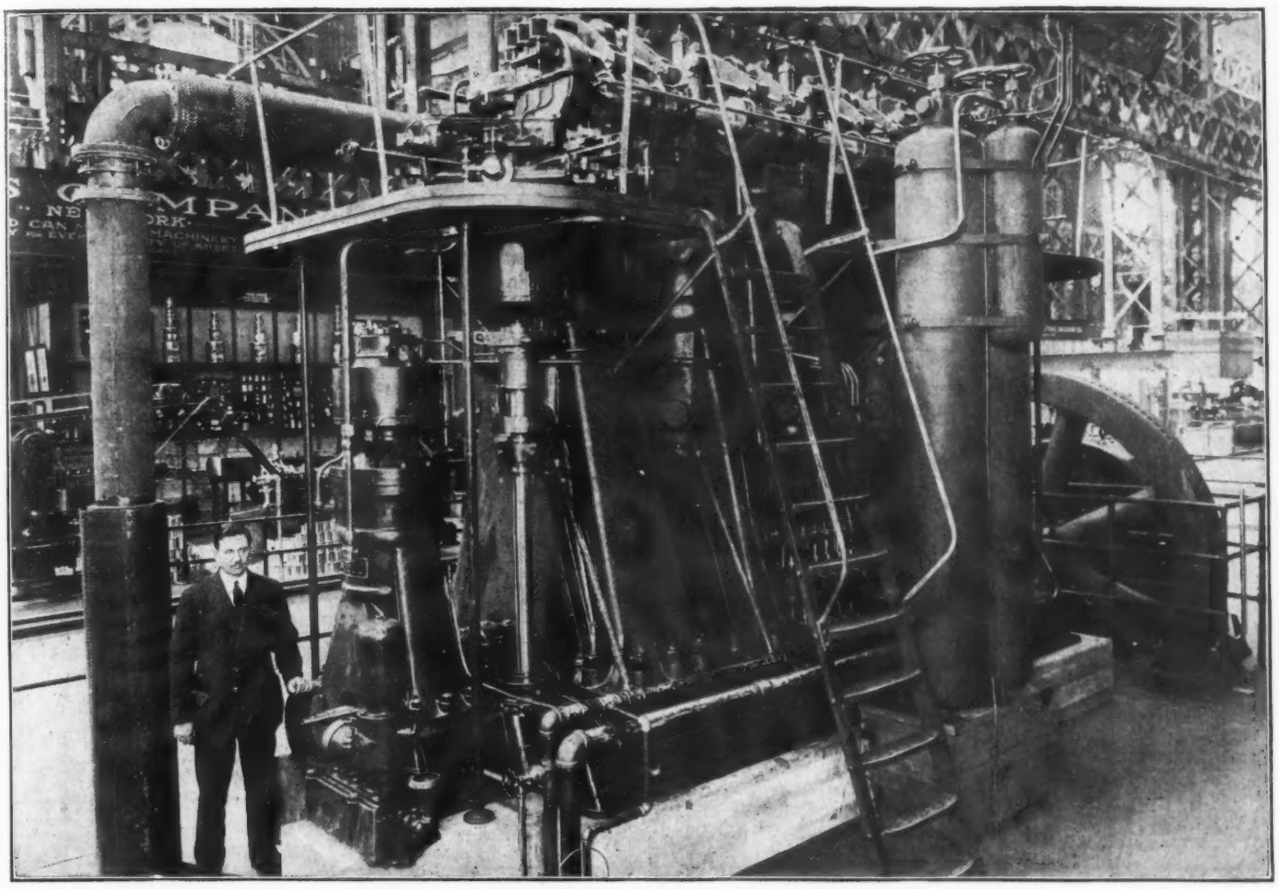

FIG. 14. THE McINTOSH & SEYMOUR 500-HP. DIESEL ENGINE

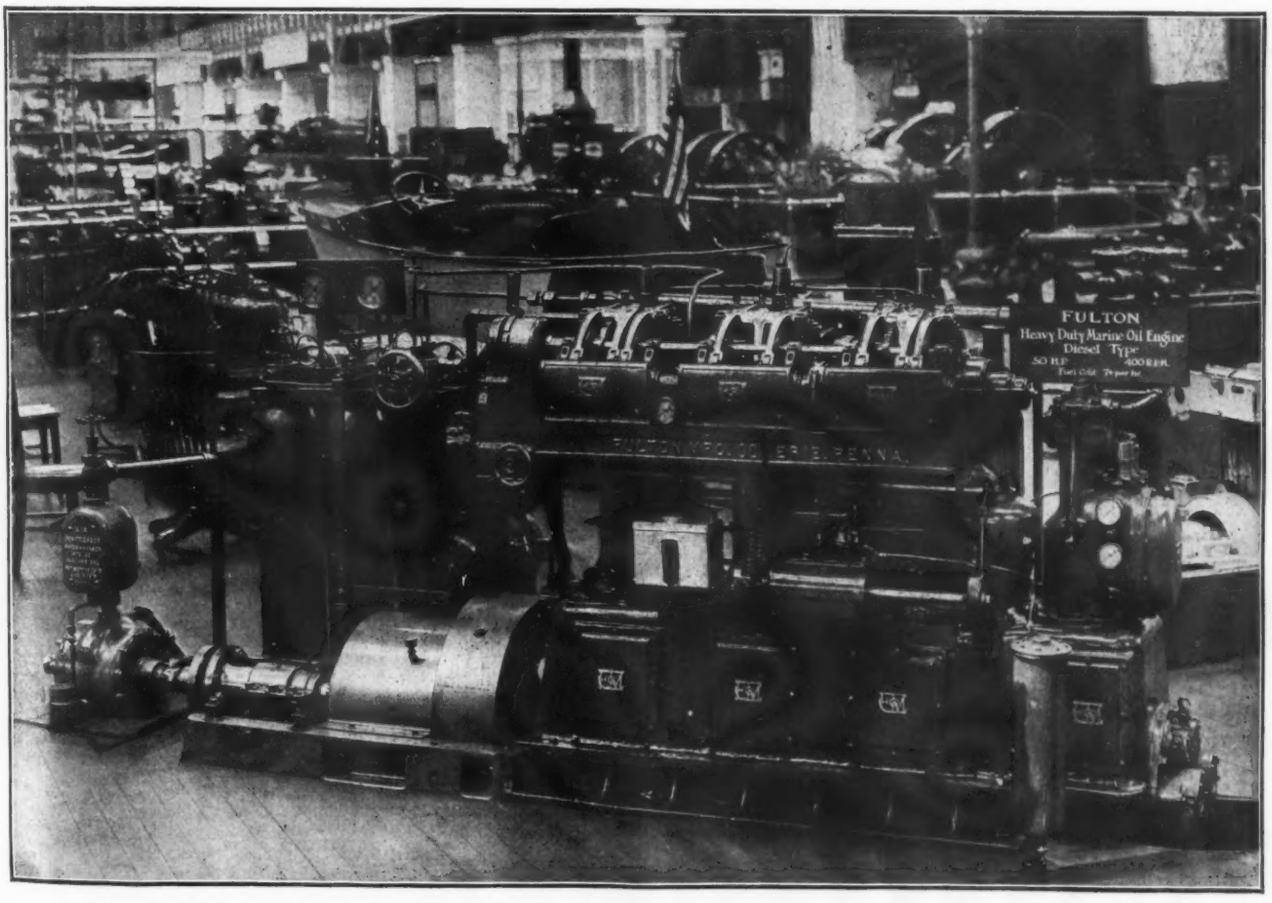

FIG. 15. THE FULTON MANUFACTURING CO.'S 50-HP. DIESEL ENGINE

out from the new St. Louis factory and represents Sulzer practice adapted to American conditions. It is shown on a larger scale in Fig. 12.

The McIntosh & Seymour space, a reproduced photograph of which is shown in Fig. 11 is designed to represent more nearly practical engine-room conditions and contains, or will probably contain at the time this goes to press, two Diesel engines besides the steam engine. The 500-hp. engine shown in the illustration has been running since May and is a McIntosh & Seymour type A engine having individual A frames. The installation of the smaller engine has been necessarily postponed by reason of delay in receiving drawings from Sweden incident to the disturbed conditions in Europe. It is now ready for testing at the McIntosh & Seymour Works and is one of their type B engines of 3 cylinders, having a box frame provided with unusual facilities for giving access to interior parts. This engine is similar to the type A engines outside of the difference in framing and a camshaft enclosed in a trough instead of in the open as on type A. Both engines follow the designs of the Aktiebolaget Diesels Motorer (Swedish Diesel Engine Co.) of Stockholm in all respects, the only departure being in the governing mechanism, which controls the amount of oil fed by regulating the stroke of the pump instead of the duration of opening of the suction valve, as in Diesel's own practice and that of his licensees, or of control of a bypass on the delivery, as in the Erie Fulton. There is a water rheostat which will carry somewhat more than the full load of their larger engine. Fig. 14 shows the 500-hp. engine from the side away from the aisle.

The Nelseco (New London Ship & Engine Co.) engine shown in Fig. 13 operates the pump which furnishes water to the impact water wheel in the Pelton-Doble exhibit. Its builder, the New London Ship & Engine Co., is the American licensee of the Augsberg-Nurnberg A. G. of Germany, builds from its designs, largely for marine use, and has installed a number of engines in submarines for the United States Navy.

The remaining example (Fig. 15), a small marine engine by the Fulton Mfg. Co., of Erie, Penn., is a part of the collective marine propulsion exhibit of Henry C. Hyde. The main characteristics of these engines are given in the accompanying table.

The Diesels are all vertical, four-cylinder, four-stroke-cycle, single-acting, with trunk pistons. In only one instance, the Busch-Sulzer, is the piston water-cooled. McIntosh & Seymour makes pistons up to 21½ in. in diameter, developing 175 hp. per cylinder without such cooling. The New London Co. has made no cylinders above 13 in. and the Fulton Co. has made so far only the 8-in. size, which do not, of course, require cooling in the four-stroke-cycle type. In the two-stroke-cycle type the necessity for water cooling the piston commences considerably earlier than in the four-stroke cycle type on account of the greater frequency of the combustion stroke.

The initial and mean effective pressures in the Diesel engine are much higher than those in the steam engine, but the frequency with which this pressure is applied in the four-stroke-cycle, single-acting, trunk-piston type is only one-quarter of that in a double-acting steam engine. In order to keep down the weight and cost of engine per horsepower it is necessary to use a sizable bore, notwithstanding the high pressure, and this requires attention to frame and bearing design, and massiveness of construction in the larger sizes. The mean effective pressures necessary are given in the table on page 262.

Writing Specifications

By Dexter S. Kimball*

Anyone who has had any extended experience in working from specifications must have been impressed with the many and manifest defects of the majority of these documents. Vagueness, ambiguity, contradiction, repetition and omission are a few of the ills that specifications are subject to, and rarely indeed does one find a case of any importance that has escaped all of these defects. I have before me four sets of specifications written by different engineers all for the purpose of specifying mechanical stokers for boilers whose capacity in each case did not differ greatly. The most striking characteristic of these documents is their utter dissimilarity, not only in their general form, but also in the widely different manner and degree in which the requirements of the problem are stated. It would be interesting to know to what degree each specification made clear to the several bidders just what was wanted and required in the stoker line and also to what extent the requirements were met by the stoker selected. I have also a set of specifications for a boiler and mechanical stoker that were to be installed in a certain building belonging to the United States Government at Washington, D. C. The specifications for the boiler are carefully drawn, but aside from the statement that the bidder shall submit detail drawings and specifications covering the stoker that he proposes to furnish, no mention is made of the stoker in the body of these documents. This seems remarkable, indeed, when one considers that the Federal regulations make it mandatory to award the contract to the lowest bidder whose tender satisfies the specification. In the case under discussion considerable latitude is certainly allowed so far as this requirement is concerned.

If the purchaser simply wishes to know what apparatus is to be had and is willing to trust to the wisdom of his own selection, the specifications can be very elementary and trade catalogs will answer for tenders. But if, as is most usual, the buyer wishes to solicit open competition, but wishes also to insure that the apparaus installed will give the results desired, carefully written specifications are a necessity, and if properly written, they are an aid to all interested in the problem.

It is very easy, of course, to criticize some other fellow's work, but when confronted for the first time with the problem of writing a specification, one is likely to be a little more sympathetic. If the reader should doubt this, let him try his hand at writing a specification for

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some fairly complex, but quite familiar, machine. Usually, the first thing the beginner does is to get together all the specifications he can find bearing on the particular problem in hand. In general, he will get just such an impression as I have suggested in connection with the four stoker specifications, though much valuable aid is to be had from such sources. There are a number of books on specification writing that may also be of assistance to either the novice or the experienced engineer.

Two qualifications are essential on the part of a writer in order to produce good specifications. The first of these is familiarity with the apparatus to be specified. Unless the engineer has made himself fully conversant with the needs of the situation and the characteristics of the machinery needed to meet these needs, his specifications will be like a description of Jerusalem by one who has never visited the place. We see many such specifications. It should be noted also that the writer of specifications cannot dodge the issue by omitting to mention those features with which he is not familiar. The omission of necessary statements is as great a fault as the erroneous or faulty statement of others. There is no one thing that will show with such vividness an engineer's lack of knowledge of any piece of apparatus as his efforts to write a specification for it; and the writer makes this statement with the memory of some personal experience in mind.

The second essential qualification on the part of the writer of specifications is the ability to express himself in good clear English. It is beyond the limits of this article to discuss this phase of the matter, but anyone who has had much experience in working from specifications will agree heartily with this statement, and almost any specification will furnish illustrations of the point. Thus, in one of the stoker specifications previously referred to the following statement occurs: "There shall be bids on stokers of the underfed type, the overfeed type and the chain-grate type of stokers." From this the prospective bidder would infer that he must bid on all these types, when really what the engineer meant to say was that tenders for these types would be received. The art of writing good English can be acquired only through practice, but if any writer of specifications will simply read his finished production with his mind in the attitude of one who must work from them, such expressions as that just quoted and much of the ambiguity, contradiction, vagueness, repetition and unfairness that characterize so many documents of this kind will be eliminated.

Should the engineer be fortunate enough to possess these qualifications in a large degree, he can still derive considerable help by carefully studying the form of the specification he is about to write. Just as making a drawing helps to make clearer to the designer the work he is prosecuting, so making an outline of a specification assists in obviating contradictions, repetitions and omissions. Some time ago the writer was called upon to write quite a number of specifications covering the remodeling of a large central power and heating station covering steam, electric and hydraulic apparatus of considerable variety, and it was highly important that these documents should be correct as far as possible. A careful study was made, therefore, of the form of such instruments with a view of obtaining, if possible, the form that would seem to be most logical. For it was felt that there must be a logical form to such documents, just as there is to almost any descriptive matter. In every case, the specifications obtained just what was needed without question as to their intent, and the writer has always felt that not a little of this success was due to a careful consideration of the form that was adopted. This form is as follows and is submitted in the hope that it may be found useful:

FORM OF SPECIFICATION

A. General Instructions and Conditions.
B. The Specification Proper.
  (1) General description and requirements. Itemization.
  (2) Detail specifications of each item in the following sequence as far as possible:
    (a) Type.
    (b) Capacity.
    (c) Details of Construction.
    (d) Performance and Efficiency.
    (e) Inspection and Tests.

Under A is included all general instructions and conditions peculiar to the work such as guaranty, patent right, delays, etc.; or in other words, the financial and general business aspects of the work that will naturally form the basis of the legal contract if such is made and which is separate and distinct from the specifications, though necessarily based upon them.

Under (1), General description and requirements, a full statement should be made of just what the work is to consist of, paying special attention to where it begins and ends with reference to other work, and specifying exactly what the contractor is to furnish and what the purchaser is to furnish, bearing on the work.

Here also the work should be itemized or separated into the parts necessary or desirable either for clearness or for the purpose of securing separate bids on different classes of apparatus. This procedure often enables the purchaser to secure a lower price by selecting the lowest bids on the several items instead of letting the contract to the bidder whose price on the entire contract may be lowest.

The remainder of the outline is self-explanatory, but it should be said that while the sequence is arbitrary and need not be as laid down in the foregoing, some such standard form will be found very helpful in avoiding repetitions, contradictions and omissions.

There is one item, however, which is not considered carefully enough, namely, that covering performance and efficiency. It is not sufficient, in general, to specify simply that the efficiency of the apparatus in question shall be a certain percentage. It is often necessary to specify just what is meant by efficiency. Thus, in specifying an electric generator it is not sufficient to specify that the electrical efficiency shall be, say, 95 per cent., but it must be stated whether this does or does not include the energy of excitation. Items of this character should be written with special care if the purchaser expects to live up to his specifications.

Specifications should tell clearly what is to be done and not give suggestions regarding the work. Thus, the expressions so often seen in architects' specifications, such as "Paint on walls to be," etc., "Lay all foundations," etc., are bad English and generally indefinite. And finally, specifications should be fair to both purchaser and contractor. Nothing should be put into them that it is not the intention to enforce and fairness demands that they tell the contractor of any difficulties that he may not foresee, but which are known to exist. The avoidance of such vague terms as "a workmanlike manner," "about," "as directed by the purchaser," would make the specifications more definite and fairer to all concerned.

Central-Station Rate Making

By Paul J. Kiefer

SYNOPSIS—An analysis of the charges entering into the cost of furnishing central-station electricity and the effect of off-peak load. An example illustrates the procedure involved.

The major basis for disagreement in rate schedules lies in the grading of charges from the small lighting consumer to the large user of current for factory power. The average individual appreciates the fundamental justness in selling any commodity at a discount or lower price, when taken in wholesale quantity; but when charged for house lighting at say, 12c. per kilowatt-hour while the large manufacturer pays only a little over 1c., his sense of justness is offended. It must be conceded without argument that far too often the small consumer suffers flagrant discrimination in exceedingly unjust rates. The very form of the evolution of the central-station industry has been one logical cause of this condition. In a letter in *Power*, Mar. 9, 1915, F. F. Chandler expressed the situation by saying: "When electric plants first came into use they furnished current for lighting only, and their total cost for doing business was therefore charged up to the current sold for this purpose. It did not take long to learn that if this same equipment could be operating in the daytime, they could afford to sell current cheaper during the day than at night provided they could continue to charge the cost of doing business up to the light consumers." A second cause is that in order to secure power business the central station is compelled to meet either actual or proposed isolated plant competition. Having a virtual monopoly otherwise due to its municipal franchise, there exists no competition in the lighting field, and the management feels justified in charging the small consumer all the traffic will bear.

In recent years, however, with the awakening of the light-consuming public and the introduction of the public-service-commission idea, intolerance of the existing conditions has arisen. The result has been the development of innumerable systems of rate-making. Some, presented by the central-station people, are purely attempts at justification of existing grossly discriminatory rates. Other extremes have only been the efforts of small users to show why they should slide from under their just share of expenses and profits.

The problem of rate-making is the evolution of a rate schedule whereby each individual consumer in any group is charged his proper proportion of the company's required gross income. There are two basic theories of utility rates. The one originally recognized by public utilities as the only sound principle, and still officially supported by the National Electric Light Association, is that commonly called the "value-of-service" theory. It means that, from the law of supply and demand, the public-utility company believes itself justified in charging the wholesale user just enough to defeat the competition of any present or proposed isolated plant, even though in so doing the revenue derived may fail to cover but little more than the bare cost of the fuel, station labor, oil, line maintenance, etc. Because the average retail consumer is in no position to supply his own power his rate is so set as to cover the remainder of the company expenses plus the desired sum for profits. Under this theory the only regulating agent is competition.

The other theory, now universally adopted by public-service commissions, is termed the "cost-of-service" theory. Its basis is a proportioning of the cost of each type of service, this proportion plus a fair profit being borne *pro rata* by each consumer. Considering the utility business as a publicly protected monopoly, it cannot well be denied that the cost theory is the only just and equitable one if at the same time the rate-regulating body appreciates its responsibility to the utility company in return for restricting its net earnings and for the various other obligations placed upon the company.

Analysis of Central-Station Costs

Central-station costs are of two classes: The first, or variable class, covers those expenses which rise and fall with the increase and decrease of the station output; the second, or fixed class, are those which are largely independent of the output, but go on each day whether the station is loaded to full capacity or whether it is almost idle. In the first, or variable, part belong undoubtedly the fuel, oil and waste, water and the major portion of the generating-plant labor. For special-customer groups this class may include additional items such as street-lamp trimming and renewals and incandescent-lamp renewals. It may also be argued that, to provide incentive to the company for healthy increase in sales, this class should include that portion of the allowed profit which is over and above a fair interest rate on the investment.

The second, or fixed, part includes interest on investments (likewise additional profits if not covered as stated), taxes, depreciation and obsolescence of equipment, insurance, administrative salaries, station upkeep, and all items that go on whether the plant is in full operation or not. This second part is again broadly divisible into two parts. The one covers those costs which are separately caused by each individual consumer, such as meter reading, billing and fixed charges on meters. The other covers the remainder of the second part and, generally speaking, each consumer's share is dependent on the proportional part of the station equipment that is necessitated by that consumer's power demands.

Recapitulating, the total charge T to each consumer should cover, in some form the three items mentioned. These are commonly called, in the order as given: Energy charge, E; consumer charge, C; demand charge, D—also called the capacity charge, or the "readiness to serve" charge.

$$T = E + C + D$$

The first is a flat rate of so many cents per kilowatt-hour consumed, possibly derived by dividing the total variable yearly expenses by the total yearly kilowatt-hours sold. The second is a fixed sum per month and is the cost of the consumer to the company regardless of whether he uses any current or not. It is really the direct tan-

gible outlay that the company incurs in installing, reading and accounting his particular meter.

The third is the most difficult to determine. In considering it the fact must be kept in mind that there is no economical means of storing electric current, as there is with gas. The central station can only generate as energy is required. This may be briefly analyzed as follows: Each individual consumer will impose a certain maximum demand, which he expects the station to be ready to meet instantaneously. All other consumers of the same class will likewise have their periods of maximum demand, which may or may not occur simultaneously. At any rate, any group of consumers of the same class will, as a group, have a period of maximum demand on the station; that is, a peak period when the sum of their simultaneous demands is greatest. This probably will determine the necessary capacity of their distribution system. Carrying the analysis still further, there will be some time in the day, month or year when, from overlapping the several group-load curves, the sum of the various simultaneous demands of each class will impose a general station maximum load or peak, which will determine the necessary capacity of the central station. The fixing of a customer's "demand" charge is, then, the problem of saying what proportion of the distribution-system and central-station fixed expenses are incurred by said customer. At the present time the majority of utility companies, which charge on some such basis, make this charge proportional to the consumer's maximum demand, which is measured directly by recording wattmeters in the case of wholesale power consumers. It is usually approximated from experience in the case of retail consumers whose requirements do not justify the installation of such meters. Even on this system, however, there is ample room for disagreement. A common procedure is to measure or assume the maximum demand of each consumer and to charge, *pro rata,* that proportion of the foregoing fixed expenses which their maximum bears to the sum of the maximum of all the consumers. There are opponents to this plan who present very sound arguments to show that the demand charge to any definite class of consumers should be based on the degree in which that class shares in the station peak load. Theoretically, this basis is probably the more equitable one; but practically, a station may not be so equipped with switching and metering apparatus as to be able to determine this division of peak load.

The foregoing will serve to present briefly some of the major considerations involved in the problem of rate making. However, it is not intended to convey the impression that the three items mentioned must appear directly, as such, in the customer's bill. Quite equitable systems are in use in which only an energy charge or, at the most, energy and demand charges appear. Some of these handle the several classes of retail consumers with sliding rates per kilowatt-hour in connection with minimum charges per meter. With wholesale consumers there may or may not be a distinct demand charge in addition to the energy charge. A simple example of the foregoing analysis is presented here:

Capacity of plant (rated)	3000 kw.	
Cost of station, offices and transmission system (appraised replacement value)	$800,000	
Yearly expenses—Fixed		
Station and system upkeep, administration and superintendence, general legal and advertising expenses, etc.	75,000	
Interest on investment at 5 per cent.	40,000	
Depreciations, taxes and insurance at 7 per cent.	56,000	
		$171,000
Meter reading and inspecting, billing, etc.	10,000	
		$10,000
Additional profit on investment at 3 per cent.	24,000	
Yearly expenses—Variable		
Fuel, water, lubricants, station labor, etc.	85,000	
		$109,000
Total		$290,000
Total connected load (rated), 10,400 kw. divided as follows:		
Residence lighting (private residences)		
2500 consumers, 1 kw. each	2500 kw.	
750 consumers, 2 kw. each	1500 kw.	
3250 consumers, total connected load of		4000 kw.
Commercial lighting (stores and office buildings)		
100 consumers, 6 kw. each	600 kw.	
40 consumers, 15 kw. each	600 kw.	
10 consumers, 30 kw. each	300 kw.	
150 consumers, total connected load of		1500 kw.
Street lighting (city)		
640 lamps, 625 watts each	400 kw.	
Total connected load of		400 kw.
Commercial motor service (small motor installations)		
20 consumers, 20 kw. each	400 kw.	
10 consumers, 40 kw., each	400 kw.	
30 consumers, total connected load of		800 kw.
Wholesale motor service (factory power installations)		
10 consumers, 100 kw. each	1000 kw.	
6 consumers, 200 kw. each	1200 kw.	
3 consumers, 500 kw. each	1500 kw.	
19 consumers, total connected load of		3700 kw.
3450 consumers, gross total connected load of		10400 kw.

Total kilowatt-hours sold per year = 8,358,000 (see below)
Average load (8760-hour basis) = 954 kw.
Plant factor = 31.8 per cent.
Sum of individual maximum demands = 6541 kw. (see below)
Resulting unit costs:

$$\text{Consumer charge} = \frac{10{,}000.00}{3450 \times 12} = \$0.242 \text{ per month}$$

$$\text{Demand charge} = \frac{171{,}000.00}{6{,}541 \times 12} = \$2.1785 \text{ per kw. demand per month}$$

$$\text{Energy charge} = \frac{109{,}000.00}{8{,}358{,}000} = 1.304 \text{ c. per kw.-hr.}$$

ASSUMED LOAD CONDITIONS

	Individual Maximum Demand, kw.	Sum of Individual Maxima, kw.		Group Maximum, kw.	Individual Energy-Use, kw.-hr. per Month
Residence lighting					
1-kw. connections	.65× 1.0 = 0.65	2500× .65 = 1625			27
2-kw. connections	.50× 2.0 = 1.00	750× 1.00 = 750			
			2375	2775×0.7 = 1660	52
Commercial lighting					
6-kw. connections	.90× 6.0 = 5.4	100× 5.4 = 540			300
15-kw. connections	.90× 15.0 = 13.5	40×13.5 = 540			1000
30-kw. connections	.90× 30.0 = 27.0	10×27.0 = 270			2500
			1350	1350×0.85 = 1148	
Street lighting		1 consumer			
640-.625-kw. lamps	1.0 × .625 = .625	640×.625 = 400			
			400	400	187.5
Commercial motors					
20-kw. connections	.6 × 20 = 12.0	20×12 = 240			1000
40-kw connections	.6 × 40 = 24.0	10×24 = 240			2000
			480	480×0.5 = 240	
Wholesale motors					
100-kw. connections	.55×100 = 55.0	10×55 = 550			8000
200-kw connections	.53×200 = 106.0	6×106 = 636			18,000
500-kw. connections	.50×500 = 250.0	3×250 = 750			49,000
			1936	1936×0.6 = 1160	
Totals			6541	4608	

CHARGES TO CONSUMERS

	Group Energy Use, kw.-hr., Per Month	Per Year	Consumer	Individual Monthly Charge, Dollars Demand	Energy	Total	Equivalent Rate per kw.-hr., Cents
Residence lighting							
1-kw. connections.....	67,500	810,000	0.2415	1.4160	.3521	2.0096	7.44
2-kw. connections.....	39,000	468,000	0.2415	2.1785	.6781	2.0981	5.96
		1,278,000					
Commercial lighting							
6-kw. connections.....	30,000	360,000	0.2415	11.7642	3.9124	15.9281	5.31
15-kw. connections.....	40,000	480,000	0.2415	29.4106	13.0414	42.6935	4.27
30-kw. connections.....	25,000	300,000	0.2415	58.8212	32.6034	91.6661	3.67
		1,140,000					
Street lighting							
640-0.625-kw. lamps...	120,000	1,440,000	.....	1.3616	2.4452	3.8068	2.03
Commercial motors							
20-kw. connections.....	20,000	240,000	0.2415	26.1428	13.0414	39.4257	3.94
40-kw connections.....	20,000	240,000	0.2415	52.2856	26.0828	78.6099	3.93
		480,000					
Wholesale motors							
100-kw. connections....	80,000	960,000	0.2415	119.8211	104.3311	224.4937	2.81
200-kw. connections....	108,000	1,296,000	0.2415	230.9279	234.7450	465.9144	2.59
500-kw. connections....	147,000	1,764,000	0.2415	544.6414	639.0281	1183.9110	2.42
		4,020,000					
Totals.....	696,500	8,358,000					

GROSS REVENUES

	Gross Revenues (Dollars per month)
Residence lighting	
1-kw. connection.....	2500× 2.0096=5022.60
2-kw. connection.....	750× 2.0981=2323.69
Commercial lighting	
6-kw. connection.....	100× 15.9281=1592.81
15-kw. connection.....	40× 42.6935=1707.74
30-kw. connection.....	10× 91.6661= 916.66
Street lighting.....	640× 3.8068=2436.39
Commercial motors	
	20× 39.4257= 788.54
	10× 78.6099= 786.09.
Wholesale motors	
	10× 224.4937=2244.93
	6× 465.9144=2795.48
	3×1183.9111=3551.73
	24,166.67
Gross revenues per year.....	24,166.67×12 =$291,000

It may be advisable to consider several of the main features of the analysis. Primarily, it is shown that one of the major elements of cost is the fixed charge on the investment, and that the ratio between demand and energy charges varies from ½ (street lights) to about 3½ (small residences); that in general this ratio varies inversely with the number of hours per day or month that the consumer uses his equipment, and that the greater this ratio, the higher the equivalent rate per kilowatt-hour. Another fact worthy of notice is that every connected consumer incurs cost to the company whether he does or does not actually use energy. This justifies the placing of a reasonable minimum monthly charge, ordinarily from 60c. to $1 a month, although the average individual does not understand the justice of such a minimum charge and is prone to resent it.

Conclusions

A third consideration is the effect of increase of off-peak load, that is, load which does not involve any increase of station capacity. It is reasonable to assume that, in the case of the plant mentioned, there may arise an opportunity to eliminate an isolated plant and secure some very desirable wholesale business during the off-peak period if energy is offered at, say 1.6 cents per kilowatt-hour. This load will better the station-load factor and probably increase the station efficiency. The rate will bring enough revenue to cover the consumer and energy charges and a part of the demand charge. Theoretically, there should be a benefit to the retail consumer by a decrease in the energy rate because of better efficiency, and a possible decrease in demand rate due to further sharing of the station fixed expenses. More probably the cost reductions will go to swell the company's profits. However, the fact remains that strictly off-peak load does merit a special low rate.

Change this condition, however, to the more usual one, where the proposed business would have its share of the station peak and would compel present or ultimate enlargement of station capacity. The new load may better the station efficiency and thereby reduce the energy rate, but it is quite positive that, owing to the additional equipment, the demand rate will not be lowered, but more likely increased. It is questionable whether the reduced energy expense will offset the shortage in capacity charge. The rate of 1.6c. per kilowatt-hour will therefore leave a deficiency below the actual theoretical cost, which will require a higher retail rate in order to bring in the necessary gross revenue. This procedure constitutes distinctly unfair discrimination.

Considering the question entirely from the viewpoint of the central station, it is undoubtedly good policy to kill any isolated-plant competition and to secure all possible wholesale business which will pay the energy and consumer cost and some portion of the capacity cost, provided that the remainder of the capacity charge may be saddled on the retail consumer. The greatest objection of central-station managements to rigid regulation of rates on a strict cost basis is the difficulty of competing with isolated plants. However, it is not clear wherein the community or the retail consumer benefits when wholesale load is obtained at competitive rates covering less than cost and the difference comes out of the group of retail consumers. The central station has a thoroughly legitimate place in the community, and when properly designed and operated, should be able to deliver energy to the consumer at a less total cost (including profit) than many inefficiently operated isolated plants that generate their own power. The community is certainly benefited when the central station obtains all the load to which it is legitimately entitled on a fair cost basis in each case. But to throttle healthy isolated-plant competition at the expense of a general public, which confers on the utility company both fair profits and freedom from other central-station competition, is both an unfair and an uneconomic discrimination.

Chemists' Balances—Several requests have been received for the names of those furnishing chemists' balances adapted to weighing test samples of coal and other power plant-supplies, and such as mentioned on page 26 of "Fuel Economy and CO_2 Recorders" and also on page 758 of the May 27, 1913, issue of "Power," which number contains one of the lessons of the Engineers' Study Course. The following dealers carry such balances: E. H. Sargent & Co., 125 West Lake St., Chicago; and Elmer & Amend Co., East 15th St., New York City.

Electrostatic Potential and Synchronism Indicators

Electrostatic vacuum glowers are now being used to indicate the presence of potential on high-voltage alternating-current circuits, and to determine when such circuits are in synchronism and may be thrown together.

For indicating potential two appliances as shown in Figs. 1 and 2 have been developed by the General Electric Co. The first consists of an electrostatic glower, a metallic condenser hood, a switch for cutting the glower in and out of circuit, and a hook for suspending the indicator from the line and leading current to the glower. One terminal of the glower is connected to a spark gap and then to the lower end of the suspension hook, the other terminal to the condenser hood. The loop in the suspension hook enables the indicator to be hung over the line by means of the ordinary type of switch hook used for operating disconnecting lever switches.

The indicator switch when closed provides a low-resistance path between the line and the hood, and cuts the glower out of circuit. When the switch is open, the glower is connected between the line and hood through the spark gap, and will light up if there is potential on the line at least equal to the tension between the line and ground on a three-phase system carrying 15,000 volts. This indicator is used for indoor and outdoor service, and, as a rule, hangs on the line continually; but can be moved about as desired. Usually a grounded wire is connected to the switch string sufficiently close to the hood to be out of reach of the operator.

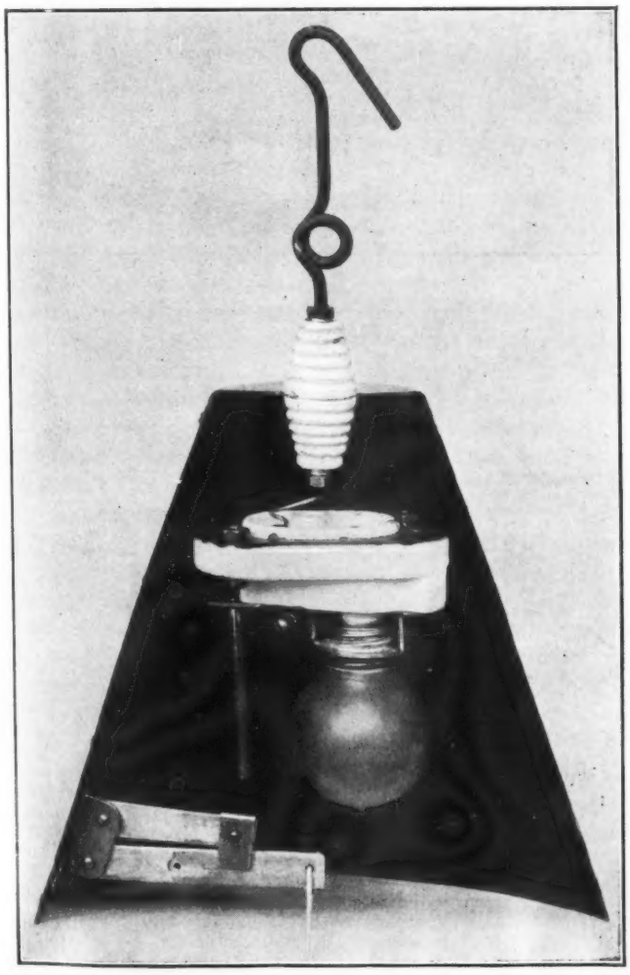


FIG. 1. CROSS-SECTION THROUGH VACUUM-LAMP TYPE ELECTROSTATIC POTENTIAL INDICATOR

The second form of indicator, shown in Fig. 2, is essentially the same as that just described, except that no switch is provided and the hood is attached to a long wooden rod carrying a ground cone for connecting a wire between the rod and ground. The upper terminus of the lead running down to the spark gap inside the hood is connected to another lead going to the top of the pole to a metal pin, which is held against the line to determine whether the line is alive. This indicator, because of its easy portability, is most suitable when the indication of potential may be desired on a number of lines.

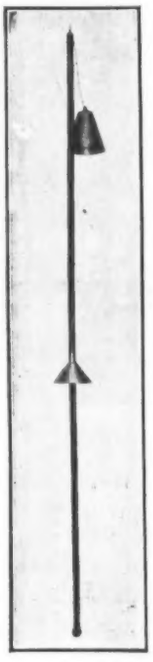


FIG. 2. PORTABLE INDICATOR

In using an electrostatic indicator one should always bear in mind the fact that, although the lighting of the glower gives a positive assurance of voltage on the line, the lack of glow does not by any means prove the line to be dead, because the bulb may be broken, the leads disengaged, the potential too low, etc.

The usual method of indicating when alternating-current lines or machines may be thrown together is by the use of a synchronism indicator and synchronizing lamps, or by either the indicator or lamps separately, employing also, as a rule, potential transformers in conjunction with the meters or instruments. This arrangement is entirely satisfactory; but when it is desired to connect systems together where transformers are not needed for indicating or measuring purposes, the equipment is comparatively expensive. The higher the voltage, the more does this apply.

The electrostatic synchronizer of the General Electric Co., shown in Fig. 3, requires for operation, however, only the charging current of the line. It consists of a few simple and inexpensive parts, and can be used to considerable advantage in main stations where current is metered on the low side, in switching stations, line junction stations and some substations.

Three electrostatic glowers, mounted in a case, which resembles that used for a round pattern switchboard instrument, are used for each synchronizer. The glowers are connected to the line through condensers consisting of suspension insulators, the insulating value of which is at least equal to that used for insulating the line.

To use the synchronizer, the terminals of one of the glowers are connected through the insulators to the leads of the same phase of running and incoming lines. The other glowers are each connected across dissimilar phases of the remaining leads of the running and incoming lines.

When the lines are not in synchronism, the glowers will indicate the relative frequency of the lines in the same

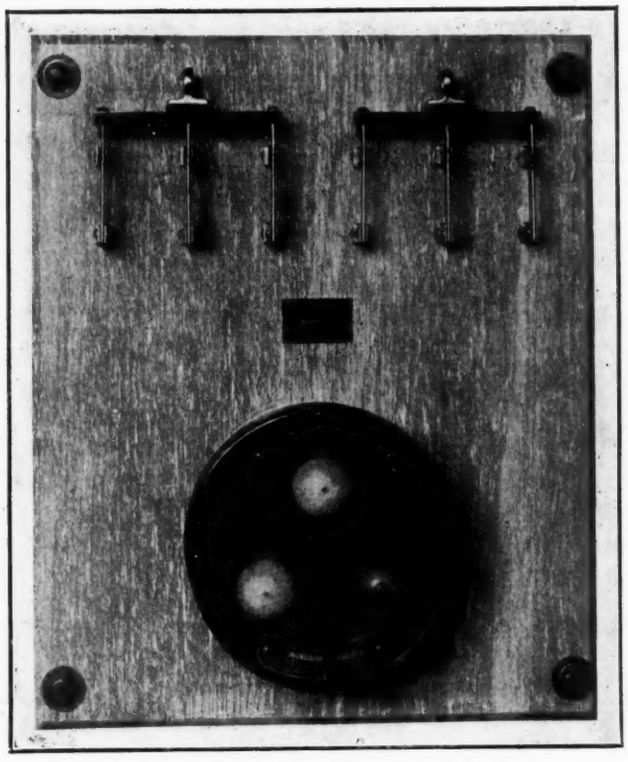


FIG. 3. ELECTROSTATIC SYNCHRONIZER

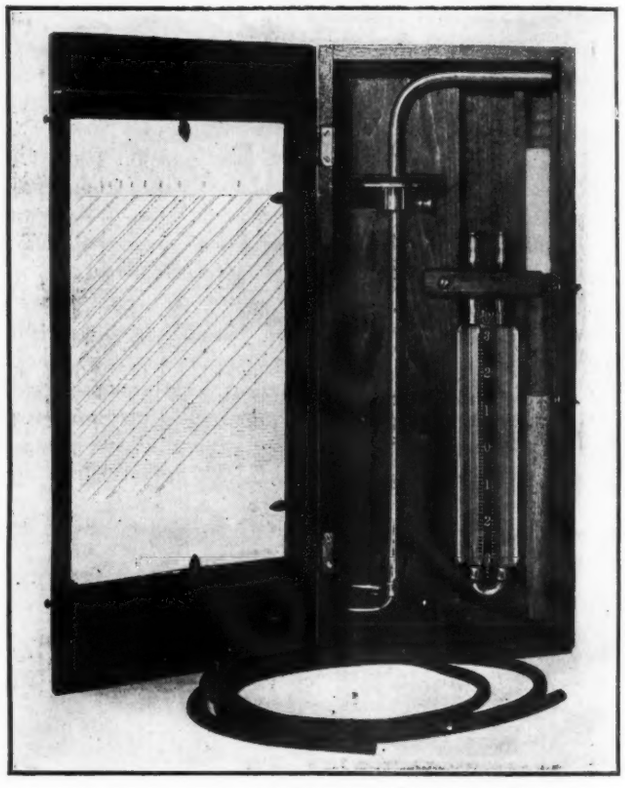
manner as the usual synchronizing lamps. When in synchronism, the rotating effect will disappear, the glower connected to the corresponding lines will be dark and the other two will show about one-half brilliancy. The minimum voltage for operation is 13,200, and the maximum depends only on the use of the proper number of insulators.

The synchronism indicator can be used as a ground detector by connecting one terminal of each glower to ground and the other terminals to the line. A lighted glower will indicate that the line is at potential above ground, that is, not grounded.

Gilbert Air-Measuring Kit

It is generally recognized that the pitot tube is the most accurate and convenient device for measuring air flowing in ducts, provided reasonable care is employed in making the readings and proper factors are used in the formulas involved. These formulas are rather awkward for the man not well up in mathematics, and to eliminate their use the Dwight Instrument Co., 6100 Greenwood Ave., Chicago, is furnishing charts with the convenient air-measuring kit shown in the accompanying illustration. With these charts the readings from the U-tube may be transformed directly into velocity in feet per minute, volume in cubic feet per minute, or air horsepower. No preliminary calculations are necessary, so that the practical as well as the technical man may use the charts with accuracy and save considerable time. The charts are based on standard formulas for circular and rectangular ducts. In their plotting mean values were employed throughout. In other words, they are based on readings taken at the center of the ducts corrected by proper coefficients. The charts, then, are sufficiently accurate for all practical purposes, and there will be no occasion to revert to the formulas unless the requirements are extremely exacting. The foregoing plan should be followed by users of the kit—that is, the readings should be taken at the center of the duct rather than make a traverse of the entire section of the duct.

As will be apparent, the kit consists of a standard type of pitot tube, a standard U-tube draft gage having a range of 6 in., two sections of rubber tubing for connecting the pitot tube to the draft gage, a chemical thermometer and the charts previously mentioned. The outfit is ar-



GILBERT AIR-MEASURING KIT IN ITS CASE

ranged neatly in a case which is convenient to carry, and full directions are issued on how to use the equipment and obtain the desired readings from the charts.

New Orleans' Proposed Municipal-Plant

That New Orleans will shortly have a new electric-light and power plant in competition with that of the New Orleans Ry. & Light Co., which has for some time controlled the situation, became apparent when at a recent meeting of the Commission Council the offer of the railways company to cut the flat rate from 12c. to 9c. per kw.-hr. was ignored, the city having asked for a reduction to 7c. This is the final break in the negotiations which have been under way for more than a year looking to a material reduction in electric-light and power rates in New Orleans.

The long-talked-of municipal plant is expected to become a reality now, although the Algiers Ry. & Light Co. has offered to erect a plant in New Orleans and sell current at the rates set forth by Commissioner Lafaye. This proposition, however, is for the present regarded as secondary, the municipal plant coming to the fore again. The council authorized the employment of an expert to plan such a plant, and Commissioner Lafaye announced that he had been in correspondence with and had chosen F. W. Ballard, of the Department of Public Utilities, Cleveland, Ohio, for the work. Mr. Ballard constructed and is successfully operating the Cleveland municipal electric plant of 25,000-kw. capacity, which is serving its patrons at a 3c. rate.

Editorials

Does Society Membership Pay?

Among the causes for dissatisfaction voiced by certain members of the American Society of Mechanical Engineers is the fact that they can rarely attend the meetings and therefore do not get an adequate return on their investment.

One cannot but wonder what such a member expected when he joined. Certainly, not that his annual dues were going to cover the expenses of going to distant meetings. Only about one-eighth of the members attend the largest annual meeting, and only about one-half that number the spring meeting. There must be, pertaining to membership, some advantages and duties, which hold the bulk of the members to the society, besides the privilege of participating in these semiannual gatherings.

In order to be elected a member of the American Society of Mechanical Engineers, one "must have shown by his experience or the responsibility of his duties that he is competent to take charge of work in his profession." Surely, the inclusion of his name in the list of members of the great national society of his profession, the right to wear its insignia, the privilege of introducing himself as such to fellow members, the publication of his name as a professional engineer, is some return upon his investment.

The accomplishments of the last century have been preëminently those of the engineer, but his works are his only monuments. Look for tributes to the engineer among the marks and records of public recognition. Do you find monuments or tablets erected to his memory? Do you find him elected to positions of honor and trust? He has been content to create for the love of creating and for somebody's money, and the financier and captain of industry have gathered the fruits and the credit of his labors.

There is an awakening to the sociological and industrial and political importance of the engineer. The people are realizing that to deal with the building and transportation and water and lighting problems of a big city, an engineer's training is of more use than that of a lawyer. The Secretary of the Navy has determined to call to his assistance the best inventive and engineering talent of the land, and has asked the American Society of Mechanical Engineers to recommend two of its members to act upon his advisory board and the Secretary of War has also asked the Society to assist in the formation of a civilian corps of engineers.

Is it any benefit and satisfaction to you as an engineer to see this belated but growing recognition coming? Have the existence and efforts of the national professional societies of civil, mining, electrical and mechanical engineers had any influence in bringing it about? Is it not worth something to have had even an humble part in it? Do you not get something back upon your investment in the greater prestige which the engineer enjoys, due in part to the society which you are helping to support?

The capital of an engineer is in his head. He is an engineer because he knows how to do things. He knows what is available for certain purposes and the manner and limitations of its use. Have you ever thought how much your society is doing to bring out and systematize and make available such knowledge, to establish standards and uniformity of practice? You might, as an isolated member of the profession, profit by its standards and codes, procure and use the information which it develops, but is it not a duty and a satisfaction to help support it and to have a part in its activities?

Every member cannot, as George Dickie once did, jump from San Francisco to New York just to read a paper and go back on the next train, but no member is so far from Thirty-Ninth Street that he cannot take an active and interested part in the work of the society. An intimation that one has ideas or information upon, or even particular interest in, any part of the work, anything that will signify to those who are trying to do things that one is ready to help and how, that will change his name, to the official who scans the list, from an abstract quantity to a live interested unit capable of helping and willing to be used, will lead to his speedy enlistment; and the heights to which he can climb in the society and in the profession will be limited only by his own capacity and accomplishment.

All this is as applicable to any other society as to the Mechanical Engineers. One cannot get knowledge by buying a book or subscribing for a paper. He must study and read them. One cannot get the most out of a society by writing a check for the annual dues, although, as we have tried to show, some societies are making good use of those dues to a general advantage in which he shares, but the man who gets the most out his membership is he who does not forget he is a member until some disturber asks him what he is getting for his money.

Accompanying the "Boss" on Inspection Trips

In plants where the chief engineer reports to a technically qualified superintendent or manager, the task of accompanying him upon an inspection is sometimes trying. No matter how hard a man may work to keep a plant in "apple-pie" order, a superior with a microscopic eye can usually find something to criticize. It is only human to feel uncomfortable when apparently trifling details are censured in the face of a commendable general plant average, but the sooner one learns to welcome criticism, the better. As long as a single item about a plant can be found at fault, the engineer and his subordinates should welcome the chance to improve it or else show the "boss" why conditions are thus and so and why they cannot be immediately changed for the better.

The first object of power-plant operation is to furnish the best service at the lowest cost consistent with safe and

continuous output, and if the log sheet shows that this is being realized, many details seem inconsequential when dragged forth by the inspecting official for immediate explanation or early action. But after all, everything is important that affects either the appearance or the service of a station, and a coöperative spirit should be exhibited even under trying conditions.

When going through an installation in this way, the chief who is prepared to answer searching questions about the detailed performance of even auxiliary equipment is wise indeed. By this is meant more than a casual expression of opinion as to the fitness of auxiliary apparatus for its service. A loose-leaf book well stocked with capacities, dimensions and test data, repair costs, etc., and stowed away in one's pocket is worth at such a time all the trouble it takes to keep it uptodate. Promptness to note the criticisms of the "boss" while they are fresh also pays, so that on the next trip as many as possible of the items mentioned may have been attended to. Executives of the scrutinizing types are likely to have long memories, and even if nothing is said about it, the engineer can rest assured that improvements recommended previously are noted, while delays in following out such orders are extremely damaging to the engineer's reputation.

Inspections may be turned to constructive account by the engineer himself, if he is prepared at such times to discuss accurately desirable changes in plant equipment or policy and to point out just where modifications can be made to advantage. Many engineers realize this, but others are content to let things drift along, and so do not get the benefit of the boss's sympathetic understanding when the proposition comes up later to spend perhaps a substantial sum of money on betterments. The inspection trip affords an admirable opportunity to prepare the management for subsequent outlays which are justified on engineering grounds, but which require a little time for consideration by a busy executive ordinarily occupied with other duties. It is a good thing for the engineer, too, for his superior to see that he is constantly studying the needs of the installation from the viewpoint of better and less costly service per unit of output. Where the inspection trip is utilized as an opportunity rather than dreaded as an annoyance, the influence upon the station and its staff alike is bound to be helpful.

Controlling Professional Enthusiasm

An engineer absorbed in his own work often overestimates its appeal to others in matters of detail. Therefore, in dealing with superior officials it is often best to control one's professional enthusiasm. It is one thing to be prepared to go as far into details as the "boss" asks, and another to thrust too many details upon him. To know what to omit in a verbal report is quite as important as to know what to include.

Suppose the advisability of installing an economizer has been put up to the engineer and after sufficient time for investigation he is asked for a report of the findings. Making allowances for the personal equation of the "boss," it is a safe guess that the engineer had better state his conclusions briefly and await an invitation before launching into a full discussion of the temperature conditions "before and after taking," the number of sections and tube sizes desirable, the cost of the "overhead" once the equipment is installed, the degree of sectionalization desirable with reference to boiler batteries, the comparative merits of different makes from the engineering standpoint, etc. Keeping something up one's sleeve for use at the psychological moment is wise, and is entirely different from being secretive for the sake of giving an impression of one's depth.

With a keen-sighted superior, the engineer need not worry about being called upon for essential details before a conclusion is reached. If a written report is required, he can put these in as an appendix, and the wisdom of filing data, assumptions and conclusions for future reference, even where no formal report is needed, is well understood. The details of economizer design, the figures that have to be made to estimate whether or not an installation is desirable in a given case, and the whole related subject of combustion and flue-gas handling, feed-water circulating and supply conditions are of technical interest and should not be neglected in working out any such problem; but the habit of being a little sparing of flooding one's superior with these technical details unless they are asked for is commendable.

Given a thorough investigation with sound reasoning and accurate computations, the results can be left to speak for themselves when the engineer's superior does not ask for methods and processes of mental attack on the problem in hand. As the responsibilities of the engineer grow, and as reliance upon his own subordinates for certain detail work becomes more and more necessary, he is bound to appreciate the value of concise verbal reports when information is needed in a hurry as to essentials only; but none of these comments are intended to imply that shallow preparation should precede brief answers to the inquiries of superiors, or that professional enthusiasm should not be cultivated along the lines where it will be of the greatest service to the engineer as a worker in applied science.

To be known as a great industrial city's "first citizen," as president of the American Society of Mechanical Engineers, as a member of learned societies abroad, and to be selected by Panama-Pacific officials as "a man eminent in the life of Pennsylvania" would seem honors enough for Dr. John A. Brashear. But the highest honor paid to "Uncle John" is the profound esteem and affection in which he is held by legions of friends for his ideals, his innate modesty and his philanthropy.

The appeal of the Secretary of the Navy to eight scientific and technical societies to select members to become part of the naval advisory board is another evidence of the Administration's conviction that governing a great country is a highly scientific business. Science enters so largely into every aspect of public affairs in this day of high specialization that a few men, let alone one department head, cannot properly handle all the problems confronting them. Science and practice will soon be walking hand in hand.

The article on "Central-Station Rate Making" (page 268) is completely in accord with the views *Power* has always held on the subject.

Correspondence

Boiler Baffling Tools

Having just completed putting in two sets of baffles in Babcock & Wilcox boilers, I was interested in reading Mr. Brownell's description of baffling tools in *Power* of July 6.

In place of the tools he describes (which we had shipped but did not use) we took a piece of extra-heavy 2-in. pipe 5½ ft. long and into one end of it inserted a piece of 1 5/16-in. shaft 8 in. long, through which was drilled two 1-in. holes at right angles to each other. The pipe was then flattened to a width of 2¾ in. By placing this tool between the tubes and turning by means of bars placed in the holes, the tubes were spread apart.

The usual straight tongs, made of ⅜-in. cold-rolled steel 5 ft. long, were used for placing the brick. To facilitate turning, the brick was chamfered slightly on opposite sides. The advantages claimed for these tools are convenience, saving of time, and, as our repairman says, saving of "cuss" words. We put in a complete set of baffles, including flame plates and brick, in about four hours, which, I believe, is good time.

I would be pleased to hear from engineers having used horizontal baffles in B. & W. boilers. We have a strong natural draft, causing the flue gases to pass out at excessively high temperatures, which, I believe, could be reduced by using horizontal baffles.

E. Mendenhall.

Middletown, Ohio.

Moisture in Furnace Air

Referring again to the above subject and in reply to Mr. Liddell in the issue of July 27, on page 131, I desire to refer to the A. S. M. E. code relative to the standard method of conducting steam-boiler trials. Item 6, under "Heat Balance" is listed among the losses "Heating the moisture in the air," and later the formula is given for its computation, showing that it is considered worthy of cognizance.

In Kent's "Steam Boiler Economy" in the report of certain experiments on page 148 is the following: "That the ashes produced by a steam jet were never as low in carbon as those produced by the fan; that is, an appreciably larger per cent. of carbon was utilized by the fan blast, and this appears to be due to the fact that when the carbon in the ash over the grate is reduced to a certain point, the steam dampens it somewhat, it ceases to burn sooner than it does when dry air only is blown through it."

The conclusion on page 151 is that the saving of fuel by the use of the fan blower as compared with the steam blower was 13.9 per cent. taking into account the steam used by each blower.

On page 164 the following occurs: "The steam jet is in itself a wasteful appliance, for even if the steam is decomposed and the gases afterward completely burned, forming steam again, it escapes from the boiler superheated to the temperature of the flue gases, which temperature is always higher than that of the steam jet, and there is a consequent loss of heat due to superheating."

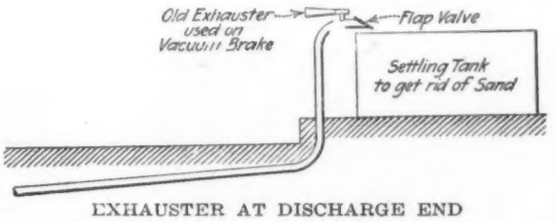
The original quoted clipping was sent in for the purpose of a healthy discussion of the subject, and I am pleased to see that it has produced that effect.

Leon Lewis.

Brooklyn, N. Y.

Priming Centrifugal Pumps

I have been greatly interested in the letters dealing with priming of centrifugal pumps. About twenty years ago we installed a centrifugal river pump to supply water for boiler feed. The suction at low water was about 5 ft. and the total lift 30 to 40 ft., and the combined length of the suction and discharge lines was about 300 to 400 yd. We used an old vacuum brake exhauster



EXHAUSTER AT DISCHARGE END

connected at the discharge end, which drew the air out of line, bringing water up into the pump casing, so that there never was any trouble to start. The flap valve at the discharge end of the line was free to open when water came and required no attention. There was no foot valve used.

We had trouble in losing water when the river was low, and at first thought it was due to air leaks in the suction line. But we found the trouble to be air sucking in at the end of the pipe (a whirlpool effect from the surface). We could see air funnels running down, and after a time suction would break. A little damming overcame the trouble.

Chas. A. Bunting.

Swarthmore, Penn.

Centrifugal Boiler Feed Pumps

In *Power* of July 27, page 132, Mr. Richardson invites a discussion of the reason why centrifugal pumps have not been more generally adopted for boiler feeding. I have about concluded that much is due to mental inertia.

In the construction and rearrangement of a number of plants with which the writer has been connected, suggestions to install centrifugal boiler feed pumps have been met with some skepticism regarding their practicability and with a "let-the-other-fellow-do-the-experimenting" attitude. This no doubt is due to the rapid advance made in the design of this type of pump, having outstepped the prospective user. Textbooks of comparatively recent date cover the subject with a bare de-

scription and the stereotyped statement that "centrifugal pumps are inefficient at high heads and are seldom used for greater lifts than 40 ft." This may have been true, say, 10 to 15 years ago, but it does not apply to the modern pump.

About a year ago a consulting engineer wagered and lost a bet that centrifugal pumps were not built for pumping to greater heads than 100 ft. Of course, this engineer was behind the times on the question of pumps, but not more so than many others. The reciprocating pump has been in use for so long, and has proved so reliable, that to replace it by so radical a departure as a centrifugal pump will require considerable pushing, as many plant owners are "from Missouri" and have to be "shown." A campaign of education will be necessary.

C. O. SANDSTROM.

Kansas City, Mo.

Centrifugal Boiler-Feed Pumps

The centrifugal boiler-feed pump is not practical for plants of less than 2000 hp. on account of the small amount of water required, although some are in use in smaller plants. The fact that only a small percentage of the plants in this country have this horsepower is one reason why there are not more such pumps sold. Another drawback is that with water at 212 deg. it is necessary to have a head on the pump suction of about 8 ft., which is rarely found in the old plants.

ALDEN L. COVILL.

Rochester, N. Y.

Centrifugal pumps have several characteristics, as a careful study of the performance curves will show. One, which at first appears to be a paradox, is that for a given pump the power required increases as the head decreases. Another is that in order to obtain any sort of efficiency there must be a relation between the amount of water delivered and the head, which is approximately that the gallons of water per minute should at least equal the head in pounds.

A plant operating at 150 lb. pressure and a load of 200 hp. would require a three-stage pump, and its efficiency would be about 15 per cent. Manufacturers do not recommend using centrifugal boiler-feed pumps for less than 1000-hp. plants, and a pump of this capacity would hardly exceed 40 per cent. A better low limit would be 1500 to 2000 hp.; then the efficiency would be close to 50 per cent. The conclusion therefore is that in high-pressure plants below 1000 hp. a centrifugal pump is very uneconomical, from 1000 to 2000 hp. its advantages offset the slightly higher operating cost, and above 2000 hp. it is the type to be preferred.

W. L. DURAND.

Brooklyn, N. Y.

Boiler Explosion in Milling Plant

The effects of excessive pressure on an 80-hp. 18-year-old horizontal fire-tube boiler belonging to the Columbus Milling Co., Columbus, Kan., are shown in Figs. 1 and 2 The explosion occurred on July 23 at 2:45 p.m., just after the engineer had fired a mixture of cobs and coal and had gone to the opposite side of the mill.

The safety valve, while previously set for 100 lb., had not been blown for some time, as the mill had been idle. The usual steam pressure was from 40 to 50 lb., and the fire was banked with 50-lb. pressure when the accident occurred.

The boiler setting was just to the right of the place where the shell landed (see lower left-hand corner of Fig. 2). The boiler was set in concrete with firebrick lining, the walls being of 6 to 1 mixture and 18 in. thick. The concrete, before the explosion, was in good condition and showed no signs of crumbling. The 2-ft. stone wall adjoining the boiler room was blown over on the engine, which is below and in back of the place where the rear head landed.

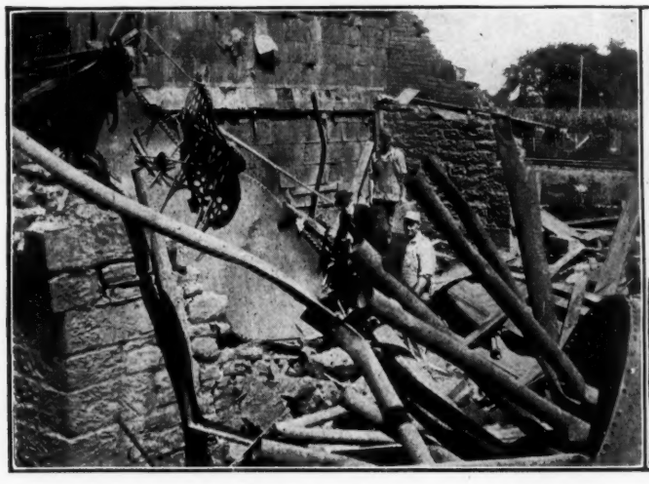


FIG. 1. OPENED SHELL AND TUBES IN FRONT HEAD

FIG. 2. RESULTS OF EXPLOSION ON NEARBY BUILDING

Six years ago a second patch was attached to the rear sheet; otherwise the boiler was in a good state. The sheet had wasted badly on the side of the patch toward the front of the boiler, and where the man is pointing, Fig. 1, it was so bent that you could hardly detect the riveteads. This part gave way first, leaving six rivets in the patch (shown at the top of the opened shell) and ripping the end seam around to the side seam. Fig. 1 also shows the condition of the tubes. Five of them had been recently installed, and while not beaded, remained tight in the front head. Half the tubes were scattered over a radius of 150 ft., one coming down and sticking

through the roof. One man was hit with a brickbat and slightly injured, but no one else was hurt. The damage was $1500, with no insurance.

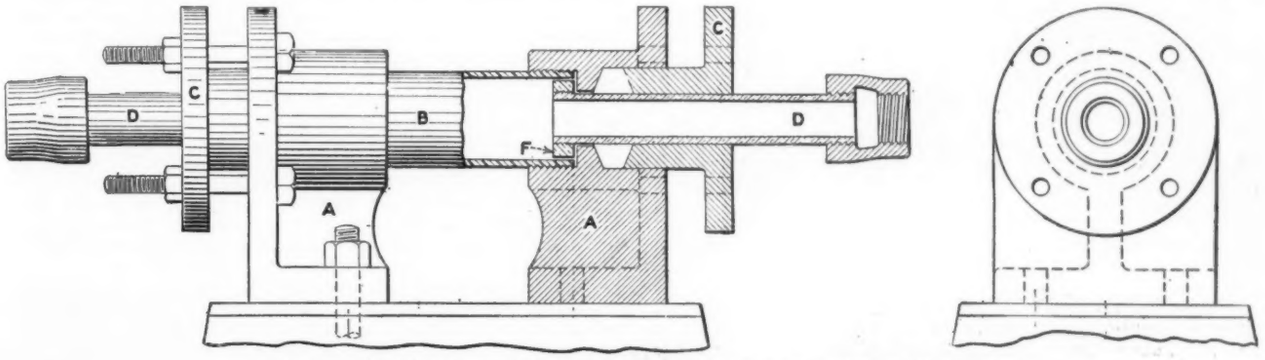
JESSE R. HAMILTON.

Columbus, Kan.

An Easily Made Expansion Joint

The illustration shows an expansion joint that is cheap, durable, and can be used to good advantage for underground steam and hot-water lines. One set of patterns can be made to finish up for at least two pipe sizes. The one described is for 1½- and 2-in. pipe.

The body *A* is made of cast iron with suitable base to be anchored to a pier or foundation. The distance piece



CONSTRUCTION OF A DOUBLE EXPANSION JOINT SHOWN IN DETAIL

B is made of 3½-in. extra-strong pipe. Gland *C* is made of cast iron; sleeve *D* is made of brass, with stop *F* on the inner end, so that the sleeve cannot travel beyond its limit. The distance piece and sleeves can be made any desired length, according to service and the travel desired.

W. A. MCGEE.

Cleveland, Ohio.

Washing and Laying Up Boilers for the Summer

It has been determined from experiments in our plant that due to the nature of the feed water it is feasible to keep each boiler in operation for 60 days without opening. At the end of that time the boiler is cut out, and after standing a few days it is emptied and the drums are cleaned out by washing with a 1½-in. hose at 110-lb. water pressure, and then scaled. The tube cleaner is then run through the tubes to remove accumulated scale.

When the heating system was shut off this spring we had two idle boilers at one time, one of which was being cleaned in the usual manner and the other to be laid up for two months. About this time one of the firemen was taken sick, and the boiler cleaner, who is relief fireman, took his place, and about three weeks elapsed before we could use the last boiler. It was full of water, and as cold as it could get. It was then emptied and the manhole and every other row of handhole plates were removed on the front end. The drum and tubes were then washed out, and we were agreeably surprised to find that all the scale could be washed off which in other cases had to be chipped off. The boiler was more easily cleaned, in about one-third the time generally required.

It is our custom to close down the plant during July and August and use central-station current (at an extra cost). During this period repairs are made to the plant if necessary and the men are given a month's vacation.

The first season the question arose: Should the boilers be left empty and open, or should they be left full of water during this idle period? We tried both ways. All except No. 4 were thoroughly cleaned inside and outside before the plant was shut down; No. 1 was filled with water to the usual level and closed tight; No. 2 was left empty and closed tight; Nos. 3 and 4 were left empty with manhole and handhole plates on the lower rows of tubes open to allow a circulation of air through the boiler.

About a week before the time to put the plant in operation again the writer was detailed to make a thorough examination of the boilers inside and outside for the purpose of finding out their condition and whether all repairs had been finished.

In No. 1, which was full of water, it was found that the drum and tubes were covered with $\frac{1}{16}$ in. of red rust, which, wherever the metal had been scratched in cleaning, had formed a little lump and pitting had started. Above the water line wherever a drop of moisture had settled a little rust spot had formed which, when removed, showed that pitting had begun, and the fine black powder that is usually found in pitting was observed.

Number 2 boiler (dry, closed up, with no moisture absorbent used) showed numerous small spots of rust where drops of moisture had collected, possibly by leakage through the main steam valve. Pitting had started at these points. As in the case of No. 1, no damage had been done. No. 3 boiler (dry, open) showed no signs of moisture, and the marks of the scaling hammer where it had left the metal bright had not rusted. This we assumed to be due to the air circulation which evaporated the moisture that might have collected in the boiler, and which could not be evaporated in those closed up. These boilers were all out of service about 10 to 12 weeks. No. 4, cleaned after the plant was shut down, was in the same condition as No. 3.

This experiment showed that in our case at least it is better to leave the boilers dry with the manholes and handholes open to admit air circulation when being laid up for some time, although in the other cases no damage had yet been done. This method of laying the boilers up has been practiced during the last five seasons with the same satisfactory results.

J. C. HAWKINS.

Hyattsville, Md.

Turbines vs. Engines in Units of Small Capacities*

By J. S. Barstow

SYNOPSIS—The author analyses the conditions under which turbines and those under which reciprocating engines should be employed. Among the governing factors are speed limitations, capacity, space, available cooling-water supply, use for exhaust steam and relative first cost.

The term "units of small capacity" as used herein is intended to include turbines and engines of less than 500-hp. capacity, including auxiliary units in large plants or central stations.

There are certain definite fields where the small turbine is of conceded superiority, and other fields wherein the engine must hold sway. The desirability of the one as compared with the other is largely determined by the following factors, which govern the adaptability, cost and economy of the equipment to be installed:

1. Speed Conditions and Limitations, involving consideration of maximum or minimum permissible speed, and whether the driven apparatus is of the constant- or variable-speed class, or such as requires uniform angular velocity in rotation.

2. Steam Pressure and Temperature Conditions, involving consideration of initial and final pressures and superheat.

3. Power Capacity of Apparatus.

4. Relative Space Requirements of Turbine and Engine Units, involving consideration of available room, character of power-house construction and cost of foundation or other supporting structure.

5. Use or Application, if Any, of the Exhaust Steam for feed-water heating, steam heating or industrial purposes.

6. Available Cooling-Water Supply, if the turbine or engine is to run condensing, involving also consideration of the temperature of the water and whether it must be artificially cooled and recirculated.

7. Operating Conditions, including consideration of attendance, oiling, starting and stopping, vibration, noise, etc.

8. Relative Cost of Complete Installations, including the necessary foundations, piping and condenser equipment, if any.

It was not until about 20 years ago that any really practicable turbine was developed, and even up until 10 years ago the turbine was looked upon considerably as an experiment. The last few years have, however, witnessed the practical perfection of this type of prime mover in sizes as large as 50,000 hp., while units of 30,000 hp. have become common in our large stations. Also, during this period much has been done in the perfection of small turbine units, as a result of which the turbine today in all sizes is quite as well developed as is the steam engine after more than 100 years of constant effort and improvement.

The writer has no intention of reflecting on the great work done by steam-engine engineers in the development of the reciprocating engine. The work of these men accelerated the evolution of the turbine, the science of thermodynamics underlying the final development and perfection of both.

The present-day builders of reciprocating engines are able to report further progress, and as a result of their recent efforts, the poppet-valve engine has been rejuvenated and adapted to the use of highly superheated steam; and the uniflow engine and small self-contained power plant, or "locomobile," have been developed.

SPEED LIMITATIONS

The question of speed limitations is of first importance in selecting the type of prime mover. Since high peripheral velocities are necessary in order to efficiently utilize the energy of a steam jet in the turbine type of apparatus, the turbine shows its lowest water rate when running at a constant, high rotative speed. Where the character of the service is such as to require speed variation or reversal in direction, or where the speed is necessarily low, the turbine is unsuited and the engine is much better adapted.

In engine installations, the minimum permissible speed has an important bearing on the question of operation. If an engine is run at very high rotative speeds, operating troubles are sure to be numerous, the upkeep excessive and the service unsatisfactory.

The lack of driven apparatus designed to run efficiently at speeds consistent with high turbine economy has in the past frequently dictated the use of engine prime movers for many kinds of work. While speed-reduction gears are by no means new, improvements in high-speed gearing, as well as in the manufacture of high-speed direct-connected generators, blowers and pumps, running at 3000 r.p.m. and over, have greatly increased the possibilities for turbine installations. Direct-current generators as small as 10-kw. capacity, and 60-cycle alternators of capacities as low as 150 kw., designed for gear drive, are now offered. The manufacturers claim for these machines that the increased efficiency of the higher-speed turbine, together with the saving effected in the generator construction by reason of the slower speed permissible in the driven end, justify the expense and complication which the gears introduce.

For power-station work, where some of the auxiliaries are usually motor-driven, the exhaust steam can be entirely condensed in the feed-water heater, and the water rate of the steam auxiliaries is not a limiting factor; while reliability, accessibility, low maintenance and labor costs are of more vital importance. Power-station designers therefore have always exhibited a strong preference for turbo-auxiliary units, and there is now a decided tendency toward geared installations.

The selection of turbines for auxiliaries is largely influenced by the high speed at which small engine units run, which makes it exceedingly difficult to keep them in continuous service and almost impossible to secure smooth, quiet operation. Such reciprocating units require close attention and must be shut down, overhauled and adjusted at frequent intervals; the maintenance is high, and serious breakdowns are by no means rare. An accident to a circulating or hotwell pump, for example, usually compels a shutdown of the main generator, with consequent loss of production, and often in the case of a public-utilities plant, loss of prestige and the incurrence of public ill-will. In all central stations, therefore, where the main units are few in number and of large size, high economy, as compared with continuous operation, becomes relatively unimportant, and turbine-driven circulating hotwell and boiler-feed pumps are almost invariably used.

Motor-driven exciters are largely used in alternating-current stations, a steam-driven exciter being provided for starting up and as a reserve unit. Here also, since the steam set is idle a large part of the time, high economy is not so important and the saving of floor space and elimination of vibration will often decide the question in favor of the turbine.

For driving fans of large capacity at low pressures, for induced draft, hot-air heating and ventilating systems and the like, the engine seems best suited. Fans built for this service ordinarily run at less than 200 r.p.m. and are usually of the paddle-wheel type, which is better suited to these conditions than the multi-blade high-speed fan. In induced-draft work, load fluctuation may require frequent changes in speed, the engine being under the control of a throttling regulator which is automatically actuated by a change in steam pressure. These conditions are quite unfavorable to turbine economy, and a suitably designed and well-constructed engine will give more satisfactory results.

Likewise, in pumping large quantities of water against low variable heads (conditions which are encountered in drainage or sewage-pumping stations) the turbine must yield to its rival. These pumps may have single runners of large diameters or may be of the multi-impeller type, but in either case, the speed is below the economical turbine range, even when a gear is used, while the engine, at low speed, has an opportunity to make the best showing, steam economy and operating troubles considered. Where the lift is variable, speed changes are important and the engine is almost always more suitable.

The use of underfeed stokers operating under heavy forced draft and capable of developing high boiler ratings has become quite common as a means of reducing fixed charges and boiler-banking losses in railway and lighting plants. For such service the high-speed multi-blade fan makes the best installation, particularly where one fan serves several boilers.

*From a paper read before a joint meeting of the A. S. M. E. and the A. I. E. E. at the Engineers' Club, Philadelphia.

as the blower units frequently become excessively large when run slower than 400 r.p.m. At this speed the engine drive is an uncertain and expensive proposition.

Furthermore, as such stokers at the best are capable of only from one-quarter to one-third their maximum capacity under natural draft conditions, a blower breakdown under a peak load is serious and the ability of the turbine to stand up under the conditions imposed justly entitles it to the preference which is accorded it.

STEAM PRESSURE AND TEMPERATURE CONDITIONS

The highly economical steam turbine must necessarily be operated condensing, but, as previously pointed out, there are many cases where high steam economy is not the most important and the noncondensing turbine often finds favor over the steam engine.

One of the large heat losses incurred in the steam engine is that due to cylinder condensation, and one of the common methods of reducing it is to limit the range of temperature through which the steam is allowed to work in a single cylinder. For this reason simple engines are better adapted for low steam pressures, while compound- and triple-expansion engines are advisable for high-pressure and high-temperature ranges, particularly if the load is uniform.

The engine as a rule develops mechanical troubles with high superheat, especially where the steam valves have much travel under unbalanced pressures. The consensus of opinion seems to be that for slide or gridiron valve gears, a temperature of 400 to 425 deg. F. should not be exceeded, while the best point for the Corliss-type engine will be found below 450 deg. F. Above these limits lubrication is unsatisfactory and distortion of the parts is apt to give trouble.

In European practice superheating is much more common than in this country, a superheater being considered quite as indispensable as a feed-water heater. The poppet-valve engine, which was first perfected abroad, is accordingly better suited for high superheat conditions than the type of gear commonly used in American engines.

A difficulty sometimes encountered with engines using high superheat is the warping of the cylinder, the curvature being caused by the higher temperature which prevails in the metal next to the steam chest. Precaution is taken by some builders to avoid such trouble by leading the steam by two independent pipes, entirely separate from the cylinder barrel, from the throttle directly to the steam valves.

For power-plant auxiliaries it would appear that turbines which experience little difficulty from high temperatures will be more and more widely adopted, while engines will be less commonly used, especially since steam pressures and superheats are constantly increasing, it being not unusual for new plants to be designed to carry from 200 to 225 lb. with superheats of 150 deg. F. and over.

With steam engines running under high vacuums, above 27 in., the great volume of steam to be handled increases the size of the engine cylinders and the size of ports through which the steam must pass, to such an extent as to make the engines very expensive if not of impracticable construction.

The turbine, on the other hand, can be designed to operate on very low terminal pressures with comparatively slight increase of cost; its action as a heat machine is such that a greater expansion can be utilized and the economy is greatly improved by any increase in vacuum. When run noncondensing, as is well known, the turbine is less economical than the noncondensing engine.

In plants where the exhaust is atmospheric and cannot be applied to any useful purpose, the engine best fills the conditions, provided space is available, and the speed may be made low enough to insure smooth, quiet running. Such an application is found in direct-current generator sets of 100-kw. capacity and larger, in hotels, office buildings and hospitals, where the exhaust is used for steam heating in winter and must be wasted for several months in the year.

CAPACITY OF APPARATUS

The lower cost of large turbine units and the smaller space taken up, along with their reliability, have practically put the engine out of the running so far as large power plants are concerned. Where 60-cycle apparatus is installed and condensing units are used, the engine has no field beyond the 500-kw. mark, while with direct-connected, 25-cycle apparatus, the engine must stop beyond the 1000-kw. limit, and with the perfection of high-speed reduction gears, it is doubtful if 25-cycle engine-driven generators can compete with turbine apparatus of even 500-kw. capacity. The reduction gear is also rapidly driving the engine from the direct-current field in units of all sizes above, say, 200-kw. capacity. At the same time, elimination of operating troubles by the use of direct-connected turbines for exciter purposes is fast causing the turbine to supplant the engine for this service.

In the case of noncondensing units, where moderate speeds are required, the engine must continue to hold the field, though special conditions may make the noncondensing turbine a factor to be considered. In this connection, one installation might be mentioned where a belted turbine of 750-hp. capacity, running at 1500 r.p.m., is used for driving the constant-speed shafting of a paper mill, it being contended that the greater uniformity in rotative speed secured by the turbine results in fewer breaks and a more satisfactory product. In this case, the steam exhaust is, of course, utilized in the driers, and the variable-speed power is supplied by direct-current motors.

RELATIVE SPACE REQUIREMENTS

Owing to the freedom from reciprocating motion, the foundations required for turbines are relatively small and light, there being little vibration to be absorbed when the alignment and balancing are well done. The small sizes can be safely operated on floors of usual construction, designed for the ordinary floor loads. There is no difficulty experienced with the transmission of vibration to the structural members of the building or to the piping system.

The small space required for the installation of a turbine gives it an advantage in water-works plants, operating against moderately high heads. The vertical triple-expansion engine, which was formerly used almost exclusively for such work, requires a strong, massive substructure to absorb the shock and distribute the weight, and a deep pit to accommodate the water end. Where foundation and other construction difficulties are encountered in this work, the cost may easily climb to a high figure, and in a case under the author's personal observation, the additional cost of the building, incidental to the use of the vertical triple-expansion engine, would have more than paid for a turbine-driven centrifugal pump, while the fixed charges on the pump alone were more than four times the cost of fuel required to run it to full capacity 10 hr. per day.

The turbine-driven pump is not capable of showing on test the high duty of the vertical triple-expansion engine, which is one of the most economical steam engines, but the great difference in the first cost often makes the turbo set preferable, especially when the saving in the building is considered.

For boiler-feed pumps of capacities higher than 250 gal. per min., the turbine is often used and, on account of its small size, usually results in a neater and more compact layout. Where regulation by throttling is unnecessary and the pumps run at or near capacity, the economy as compared with the direct-acting type is good and can be better maintained. Valve renewal and packing troubles are avoided. The overload capacity of the centrifugal type is small, and the delivery of the pump must be proportioned to meet the maximum demand, not the average boiler-horsepower requirements. In the smaller sizes the cost of turbine units is high; where the load fluctuates widely and the speed must vary, the economy is poor; and it is better to install reciprocating pumps.

In the modern plant containing large turbo-generator units space limitations in the basement arrangements are important. With the high vacuums carried, large volumes of water must be handled and the turbine drive for circulating, condensation and air-removal pumps is in many cases the proper selection. Such condenser sets have a compact arrangement, especially when a single turbine is used to drive all the pumps, which greatly relieves the crowded condition which would otherwise obtain.

The turbo-compressor supplying the air to blast furnaces under pressures ranging from 20 to 30 lb. has almost entirely supplanted the compound reciprocating blowing engine. One large concern formerly in this work has abandoned the construction of blowing engines and is now building turbine apparatus exclusively. For this service the turbine may be run from 2500 to 4000 r.p.m., and there is a great saving of weight and space, as an engine of this type is six or eight times as heavy as the centrifugal blower, and consequently costs much more.

UTILIZATION OF EXHAUST STEAM

The advantage of an oil-free exhaust in many plants is important, and especially so in manufacturing processes where steam is used. Moreover, in chemical processes where steam is used for precipitation, a small fraction of a grain of oil per gallon will often retard the process or cause the precipitate to be of an entirely different character from that obtained with oil-free steam. The separation of the oil in exhaust steam is never absolutely complete, and fatty constituents are apt to pass the separator.

Where the available cooling-water supply is limited and must be artificially cooled and recirculated, the cost of the cooling apparatus and the power required are important considerations. The conditions will, perhaps, be best illustrated

by an example: Assuming a turbine to run at 28-in. vacuum and a temperature rise of the cooling water from 70 deg. to within 10 deg. of that due to the vacuum, the circulation of 52 lb. of cooling water per pound of steam condensed will be necessary. In the case of the engine, which will operate at, say, 26-in. vacuum, other conditions remaining the same, there will be from 25 to 27 lb. of cooling water to be handled for each pound of steam condensed.

With a cooling pond returning water at 90 deg. to produce 27 in. vacuum in a turbine plant, the pumps must circulate 70 lb. of cooling water per pound of steam, as against, say, 30 lb. required to produce a 25-in. vacuum for the reciprocating engine.

From the operating point of view, the turbine possesses a great advantage in the simplicity of its construction, a factor which tends toward increased reliability and lower cost of maintenance. It can usually be more quickly started and loaded and in operation usually requires less attention than an engine unit of corresponding capacity. The lubricating arrangements are few in number and of simple design.

SUMMARY

Summarizing the foregoing, the fields of usefulness of the turbine and engine may be briefly stated to be as follows:

For condensing service, turbines are best adapted to: Direct-connected 60-cycle generators in all sizes, 25-cycle generators above 1000-kw. capacity; direct-current generators in sizes up to 1000-kw. capacity, including exciter units of all sizes; centrifugal pumping machinery operating under substantially constant head and quantity conditions, and at moderately high head, say from 100 ft. up, depending upon the size of the unit; fans and blowers for delivering air at pressures from 1½-in. water column to 30 lb. per sq.in.

For noncondensing service turbines are applicable for all the above purposes, in those cases wherein steam economy is not the prime factor or where the exhaust steam can be completely utilized, and particularly where oil-free exhaust steam is desirable or essential.

Still another field for the turbine is in geared units operating either condensing or noncondensing for all the aforementioned applications, and in addition, many others which would otherwise fall in the category of the steam engine, on account of the relatively slow speed of the apparatus to be driven.

For noncondensing service, engines are applicable for: Electric-generators of all classes excepting exciter sets of small capacity, unless belted from the main engine; centrifugal pumping machinery, operating under variable head and quality conditions and at relatively low heads, say up to 100 ft., depending on the capacity of the unit; pumps and compressors for delivering water or gases in relatively small quantities and at relatively high pressures—in the case of pumps at pressures above 100 lb. per sq.in. and in the case of compressors at pressures from 1 lb. per sq.in. and above; fans and blowers (including induced-draft fans) for handling air in variable quantities and at relatively low pressures, say not over 5-in. water column; lineshafts of mills where the driven apparatus is closely grouped; and all apparatus requiring reversal in direction of rotation, as in hoisting engines and engines for traction purposes.

For condensing service the engine is adapted to the purposes cited, particularly where the condensing-water supply is limited, and must be recooled and recirculated.

Turbo-Blowers and Turbo-Compressors*

Basically considered, turbo-blowers and turbo-compressors are similar machines, only that the former are used for low pressures and the latter for high pressures. Both classes of machines are therefore constructively different with reference to the number of stages and the delivery volume. Usually the turbo-blowers and compressors of today are built on the principle of the centrifugal pump—that is, the gas to be compressed is conducted in radial paths. Among the few designs that depart from this arrangement is the Parsons, in which the flow direction, as in steam turbines, is axial.

It is difficult to define the boundary between turbo-blowers and turbo-compressors. All turbo machines used to supplant reciprocating blowers should be called turbo-blowers.

The pressures vary between 0.3 and 3 atmospheres, according as the blower is used for blast furnaces or for bessemer converters. Under normal operation blast-furnace blowers are run under 0.3 to 0.75 atmosphere; at times double that, and the delivery volume varies greatly; while in the case of the converter blast the pressure is about 3 atmospheres and the delivery volume is approximately constant.

The capacities of turbo-blowers for blast furnaces run from 1,000,000 to 3,500,000 cu.ft. an hr., steelworks having a lower figure, or up to about 1,750,000 cu.ft. per hr. Turbo-compressors have, in general, a lower capacity, say up to 1,250,000 cu.ft. per hr., but must thus attain considerably higher pressures, 6 to 10 atmospheres. Occasionally higher capacities are reached, as in the case of three turbo-compressors recently built by the Allgemeine Elektricitäts Gesellschaft, each of which has a capacity of a little less than 3,000,000 cu.ft. of air per hr. compressed to 8 atmospheres.

In the choice of a driving medium it must be kept in mind what is to be expected of the blower or compressor in the way of regulation of the capacity and pressure. In general it can be said that where great capacity fluctuations obtain, as in the case of blast-furnace blowers, the preference is for the steam turbine, whereas with constant capacity the high-speed electric motor is used. In relatively small plants the steam turbine is used almost exclusively, as with the fixed-speed electric motor. Under such circumstances the number of stages can be kept down and thus decidedly affect the design, as the construction cost is almost proportional to the number of stages.

Essentially the design of the Allgemeine Elektricitäts Gesellschaft turbo-blowers and turbo-compressors is a series of consecutively placed bucket wheels, the number depending on the desired final pressure and the kind of gas to be compressed. It varies between 1 and 26, up to 14 being usually on one shaft, and where a greater number is called for two compressors are arranged in tandem.

Notwithstanding the water-cooled housing of the turbo-machines, the temperature rise of the gas from, say, 70 deg. F. can extend to 212 deg. Although in the later stages this phenomenon is much less in evidence, to the end that the compression finally is even closely isothermic, the total thermal efficiency is nevertheless injuriously affected thereby; so that in this respect the turbo-compressor has not so far come up to the reciprocating one.

As a general conclusion it can be said that in the first stages the cooling effect is not noticeable, but that in the last stages it is very good. The ultimate air temperature reached in the Allgemeine Elektricitäts Gesellschaft compressors under pressures from 85 to 115 lb. is about 167 deg. F. or less, depending on the temperature of the cooling water. The requirement of the latter with a 1000-hp. compressor at the foregoing pressures, for instance, amounts to about 1600 cu.ft. an hour, and increases approximately with the output.

As to the best speed, the rule is to give the smaller machines the highest possible, namely, 4000 to 5000 r.p.m., and the larger ones about 3000 to 3800.

As a minimum size the Allgemeine Elektricitäts Gesellschaft does not advise anything lower than 140,000 cu.ft. per hr. at from 70 to 85 lb. pressure for compressors and 35,000 ft. at about 20 lb. for blowers. These values might be taken as critical points, whereon the use of the reciprocating type in comparison with the turbine type would seem to be the more advantageous.

The wheels of the Allgemeine Elektricitäts Gesellschaft machines are made up of two nickel-steel disks between which the wrought-iron buckets are radially riveted. As to wheel diameters, in the case of the 3000-r.p.m. machine it is about 40 in., and decreases toward the pressure side, corresponding to the gradually smaller specific volume of the gas being compressed. For constructive reasons this decrease of diameter is not from wheel to wheel but from one group of wheels to another group, a number of similar wheels being assembled to form a group.

The Frankfurter Maschinenbau Allgemeine Gesellschaft builds steam-driven turbine compressors for outputs from 100,000 cu.ft. an hour up, and electrically driven at a minimum of 3000 r.p.m. from about 200,000 ft. up, while for turbine blowers the output is from 70,000 ft. hourly for pressures up to 40 in. of water.

In line with the belief of this concern in the least number of wheels, it is today compressing to 7 atmospheres with 12 wheels. The buckets in these last are not radially disposed as in the Allgemeine Elektricitäts Gesellschaft machines, but suggest the spiral in their arrangement.

The Frankfurter Maschinenbau Allgemeine Gesellschaft has turned out a steam-turbine-driven turbo-compressor with a free-air capacity of over 350,000 cu.ft. per hr. to 7 atmospheres and with a horsepower requirement of 1150.

The Gutehoffnungshütte builds a turbo-compressor for from 425,000 to 635,000 cu.ft. of free air an hour compressed to 7 atmospheres. The average speed is about 3800 r.p.m. The same concern also makes a three-stage turbo-blower without water cooling. The capacity is from 600,000 to 700,000 cu.ft. of free air an hour compressed to between 7 and 8.5 lb.

*From an article by O. H. Wunderlich in "Zeitschrift des Vereines deutscher Ingenieure."

Accident Prevention

SYNOPSIS—A set of safety rules made up of many well recognized, yet oft neglected, items pertaining to the power plant.

Following are the safety suggestions contained in a booklet issued by the Travelers Insurance Co., of Hartford, Conn., which apply more particularly to the engineer's domain.

Every boiler should be provided with a reliable safety valve, installed in such a way that it cannot be shut off from free communication with the boiler. Safety valves should be tested once a day, to see that they are in good working order. Steam gages and water gages should be tested from time to time, to make sure that they register correctly. The water level in the boiler should be maintained at the proper height, under all circumstances, and the chief engineer should see that this matter is in the hands of a thoroughly responsible and trustworthy man. Water-gage glasses should be guarded so as to protect the eyes of the water tender and other persons in case of breakage, but the guard that is used should not prevent a clear view of the level of the water in the glass. Steam gages and water glasses should be well lighted, so that there will be no possibility of mistaking their indications. Gage-glasses should be renewed when they become too dirty to allow the water level to be seen distinctly and certainly.

The steam piping should be properly supported and anchored, and the main steam header and other steam lines should be installed so that they can expand and contract, with variations of temperature, without being subjected to severe stresses. Pipe lines should not be run along floors in exposed places, where persons may stumble over them. Whenever possible, steam pipes should be arranged to drain back to the boiler by the action of gravity, but when this is impracticable suitable drain pipes should be placed wherever there is a chance for water of condensation to collect. Before opening any valve on a steam pipe, great care should be taken to see that the pipe is free from water. This applies with special force to the valves on steam pipes supplying engines, because it is usual for these to pass downward for a distance of several feet, just above the engine stop valve. The vertical part of the pipe becomes more or less completely filled with water of condensation when the engine is idle, and it should therefore be drained with special care before the engine is started. There should be two valves on each connection from a boiler to a steam header, one of which should be of the nonreturn type. The part of the pipe between these two valves is likely to become more or less completely filled with water, if the valve nearest the main steam header leaks and both valves are kept closed while there is pressure in the header. Drain pipes should therefore be provided for all spaces of this kind, and any water that may collect in the pipe should be carefully drained away before either of the steam valves is opened.

VALVES—OPERATING PRECAUTIONS

Valves of every kind should be opened and closed slowly and cautiously. (This is particularly true of the main stop valve in the steam line, and of the blowoff valve or cock.) Steam from a blowoff pipe should not discharge directly into a passageway, or into any place where persons may have occasion to go. Pits in boiler rooms should be guarded or covered over. Safe means of access to all valves should be provided, and walks should be provided along the tops of the boilers of each battery, to give access to the valves and other appliances. These walks should be properly railed and lighted and should extend across all the boilers, and stairs or stationary iron ladders should lead to them from the floor level. Boiler rooms should have at least two exits, and these should be located at opposite sides of the room to facilitate the escape of the employees in case of emergency.

Engineers should see to it that no repairs of any kind, however slight they may be, are made upon any boiler or other vessel or upon any pipe or fitting, until the pressure has been entirely removed; also, that no person is allowed to enter a boiler until all the valves or pipes leading to it or from it (including the blowoff pipe) have been tightly closed. The man entering the boiler should also be required to report when he is about to go into it, and again when his work is completed. If there is steam upon any other boiler in the plant that could possibly be placed in communication with the boiler that is to be entered, a danger sign should be attached to the wheel or handle of the stop vave of the boiler into which the workman is to go, and this wheel or handle should be securely locked in the closed position.

Special care should be exercised when a boiler that has been out of use for a time is again restored to service and put in communication with other boilers under pressure. In performing this operation, which is known as "cutting-in" a boiler, the steam pressure on the idle boiler should be exactly equal to that in the main steam pipe, before the stop valve on the idle boiler is opened; and when this stop valve is opened, it should be handled carefully and opened slowly and with great caution. If any unusual noise or vibration is produced, it should be closed again, immediately. Similar care should be taken in handling a blowoff valve, because many serious accidents occur in consequence of the great stresses that are produced in blowoff pipes by opening or closing their valves or cocks too quickly.

ENGINE-ROOM DISCIPLINE

Employees should not be permitted to enter the engine room unless their work requires them to do so, and they should not be allowed to remain there after the duties that led them there have been performed. No person other than those responsible for their operation should be permitted to touch any valves or other parts of the mechanism or to approach any moving part, except as this may be necessary for the performance of work that is being done under the immediate personal supervision of the chief engineer or of some other qualified person in authority. The flywheels of engines should be guarded by substantial railings, made preferably of brass or iron pipe; and when a railing is less than 18 in. from the flywheel the space between the rail and the floor should be covered in with substantial wire netting or steel plate. Foot-boards should also be provided to prevent tools and other objects from coming in contact with the wheel, or falling into the wheel pit. The storing of oil cans, tools, waste and other articles inside of the railings and the hanging of clothing upon the railings themselves should be prohibited, and employees should never be permitted to go inside the railings for any purpose whatsoever while the engine is running. The main driving belt should be boxed in to a height of at least seven feet above the floor or guarded by substantial railings or netting to a like height.

The ladders and steps about large engines should be railed, and the stagings or platforms to which they lead should also be provided with railings and toe-boards. All walks for oilers should be railed, and governor balls should be guarded when they are near the oilers' walks or any passageway or when they are so located that the engineer must go near them in the regular performance of his work while the engine is running. When the back end of the piston rod extends through the cylinder head, the space that it traverses should be railed off or otherwise inclosed, and all other dangerous moving parts of engines should be guarded in a similarly effective manner.

An independent speed-limiting device, or "safety-stop," should be attached to every engine, to shut off the steam in case the governor fails to operate properly; and devices of this kind should be tested frequently, to make sure that they are in good working order. Electric push-buttons, for quickly stopping the engine in case of emergency, should also be installed throughout the plant. The safe speed of every flywheel should be known, and this speed should never be exceeded. The engine should never be left unattended while it is in motion, and if the engineer is obliged to leave the engine room temporarily, some other competent and responsible person should be delegated to serve in his place during his absence, to meet any emergency that may arise.

Mats of rubber or fiber should be used on the most frequented parts of engine-room floors and in all specially dangerous places, in order to prevent slipping. Engine rooms should be well lighted and should be kept in a neat and orderly condition.

GUARDS FOR PULLEYS, BELTS, ETC.

All exposed pulleys, belts, gears and shafting, when within seven feet of the floor, should have substantial and effective guards of wire mesh, sheet metal, or wood, designed and installed so as to thoroughly protect the employees from all possible danger. Similar guards should also be provided about all danger points that are within four feet of elevated walks or platforms in a horizontal direction, or within seven feet of them in a vertical direction. Belts that run over passageways or workplaces should be guarded so that they can do no harm in case they break. Guards may be made removable, to facilitate the inspection, oiling, or repairing of the various parts of the mechanism, but they should never be taken off except for good and sufficient reasons, and then

only by the foreman's special order, when the machinery is stopped. Machines from which the guards have been removed for any reason, should not be operated until the guards have been replaced.

The use of elevators by unauthorized persons should be strictly prohibited, and when a regular attendant is provided, he should be cautioned against permitting other persons to operate his car. Employees and other persons should not be permitted to scuffle on elevators or conduct themselves in an indecorous, boisterous or otherwise unseemly manner. Elevator gates should be of substantial construction, and care should be taken to see that they work properly at all times, especially if they are of the automatic type. If no regular operator is in attendance, the controlling device should be equipped with a lock that will prevent the car from being moved while loading or unloading is in progress, and in addition to this a safe and effective signaling apparatus should be provided to prevent accidents that might be caused by taking the elevator from one floor by a person on another floor.

The safe capacity of every elevator should be known, and employees should be positively forbidden to allow it to be loaded beyond this capacity under any circumstances. Employees should be forbidden to step upon or across folding hatch doors over shaftways at the various floor levels, when this form of construction is used. Hatch doors, when located over elevator openings, should be surrounded by substantial shaftway inclosures or by properly designed railings, and the entrances to them should be protected by semiautomatic gates or doors or by other equally safe and effective means. Ample light should be provided at every landing, so that the platform of the car may easily be brought level with the floor and so that the passengers or freight can be handled without accident. The safety devices should be examined and tested frequently, to make sure that they are in good working order. The cables and their fastenings should receive frequent attention, and the door to the machine room should be kept locked and no authorized person allowed to enter it.

The safety of elevators depends largely upon frequent and efficient inspection, and when defects are discovered they should be remedied immediately. The routine inspections should be made by some person definitely assigned to this work and known to be competent and trustworthy; but additional periodical inspections should be made at short intervals by experts who have given special study to elevator problems.

CARE OF ELECTRICAL APPARATUS

No persons, other than regularly qualified electricians, should be permitted to handle electrical apparatus of any kind or to touch it in any way. Rubber gloves shoud be provided for all electricians. The gloves should be kept in good condition, and should be discarded when holes are worn through them. Safety belts should be furnished for men working upon overhead lines, and dark-colored glasses for men who are obliged to look at intensely brilliant arcs. Every man who is working upon high-tension conductors or apparatus should have an experienced assistant always at hand, to render aid in case of emergency. The floors around switchboards and high-tension electrical apparatus should be nonconducting, and they should be covered with rubber mats unless they are specially constructed with a view of providing effective insulation. Water should never be permitted to stand upon the floors in the vicinity of any electrical apparatus. Railings constructed of nonconducting material or well-covered with such material at all points should be placed around motors, generators, switchboards and all other high-tension apparatus. Foremen should give full oral instructions to employees concerning especially dangerous apparatus and should post conspicuous warning signs wherever these may be needed. The signs should be printed in several languages, if necessary, so that they may be thoroughly understood by all the employees. Foremen should be well-informed regarding first-aid methods and should know how to conduct effective artificial respiration work and how to deal with every emergency that is likely to arise, so that they may be able to render immediate assistance to men who may have received electrical shocks.

PROMPT ARTIFICIAL RESPIRATION

All foremen should thoroughly understand at least one of the standard methods of maintaining artificial respiration. It is not sufficient to understand the principles upon which it is based. It is important to have practical, working knowledge that can be effectively applied without the least delay. The time to acquire this knowledge is before the need for it arises, because a delay of a minute after the accident, or even of half a minute, may mean all the difference between life and death. Electric shocks and partial drowning are the most prominent causes of cessation of breathing, but there are many other causes also, and no time should be lost in giving immediate treatment when a person stops breathing for any reason whatsoever, unless it is absolutely certain that the unfortunate one is dead and wholly beyond the possibility of resuscitation.

In electric plants and other places in which accidents calling for artificial respiration are likely to occur, a considerable number of other persons should have a practical knowledge of the subject, in addition to the foremen. In such places pulmotors or other effective mechanical devices for restoring respiration should be installed; but appliances of this kind should be regarded as supplementary, and possession of them should never be considered to justify ignorance of the methods by which artificial respiration may be induced without mechanical aid. If pulmotors are installed, it should be the duty of some specially designated person to see that a plentiful supply of compressed oxygen is always on hand. Above all, it should not be forgotten that promptness of action is highly important and that the efforts at restoration should be kept up continuously for two or three hours, before hope is abandoned.

CLEANLINESS AND NEAT CLOTHING

Foremen should strive to promote personal cleanliness among the employees, not only because it is highly commendable for its own sake, but also because it reduces the danger of infection (or blood-poisoning) in case of injury. Warm water, soap and towels should be provided in abundance, and the employees should be encouraged to use them.

Foremen should give attention to the clothing worn by employees, and persons who are operating machines or working around machinery should not be permitted to wear loose-fitting or ragged clothing.

The thoughtlessness of employees and their willingness to "take a chance" even when the possibility of accident is well understood are two of the greatest obstacles with which the foreman has to deal in his efforts to secure safety. He should therefore take special pains to discourage everything of this kind and should make it perfectly plain that the management is very much in earnest in its desire to avoid accidents. He should be watchful for careless acts of every kind and should always visit the offender with an emphatic expression of his displeasure. Gross carelessness and the persistent and wilful performance of careless acts against which the offender has several times been warned should be dealt with as severely as the circumstances of the case may require. The foreman should also call attention, repeatedly and forcibly, to the fact that the workers themselves are the ones most deeply interested in the exercise of care. The employer pays for accidents only with dollars, while the workers pay for them with eyes and hands, or even with life itself.

SAFETY RULES AND REGULATIONS

Safety rules and regulations, adapted to the needs of each particular workplace, should be drawn up and brought to the attention of the employees in some effective way. Signs, placards or pamphlets may be used, according to the circumstances, but the signatures of all employees should be obtained, to show that they have read the various safety rules and understand them thoroughly. All rules and regulations should be clearly expressed, so that they cannot be misunderstood, and they should be issued in appropriate foreign languages, as well as in English, if any considerable number of the employees do not understand English perfectly. Interpreters should be freely used, wherever necessary, and foremen should never forget that some of their employees may not be able to read even the languages that they speak.

Foremen should encourage employees to offer suggestions relating to additional or superior safeguards for the machinery and the workplaces or bearing upon the improvement of the working conditions in any way. Suggestions of this kind should receive careful consideration, and they should be adopted if they are found to be practical. If they are not adopted the reason for this action should be explained to the employees from whom they came.

The success of any accident-prevention campaign will depend largely upon the nature of the relation between the foremen and the employees over whom they are in authority. The foreman should be considerate of those under him and take a genuine and sympathetic interest in their welfare, but never lose his sense of dignity and leadership, nor be cordial to the point of familiarity. He ought to maintain a certain amount of unobtrusive reserve, which will be instinctively felt by the workers, rather than forced upon their notice by arbitrary acts and orders. If both are of the right type, discipline is easier to maintain, and helps wonderfully toward the prevention of accidents. The establishing of an ideal relation between the foreman and his workers is a problem which frequently calls for all that a man has of tact and of insight into human character. Above all, the foreman must obey all the rules himself, be fair to those under him, and never be influenced by personal likes or dislikes

Recent Court Decisions

Digested by A. L. H. STREET

Condemnation of Land—A corporation organized in Pennsylvania to develop water power for commercial and manufacturing purposes is entitled to exercise the right to condemn land for necessary uses, but the power is limited by the bounds of reasonable necessity. This rule has just been laid down by the Pennsylvania Supreme Court in the case of Raystown Water Power Co. vs. Brumbaugh, 92 "Atlantic Reporter," 140.

Negligence of Electric Lineman—Within the meaning of the provision of the California Workmen's Compensation Act to the effect that no award shall be made for injury to, or death of, an employee when caused by his own wilful misconduct, there can be no allowance for the death of an electric lineman, caused by his working at live wires without using rubber gloves, in violation of a known rule of the employer; suitable gloves being available for his use. (Supreme Court of California, Great Western Power Company vs. Pillsbury, 149 "Pacific Reporter," 35.)

Warranty of Belting—If a quantity of belting was sold on a representation by the seller that it would develop certain horsepower on a lineshaft of stated dimensions, revolving a given number of times a minute, and the buyer bought in reliance upon that representation, it amounted to a warranty, entitling him to a deduction from the contract price of an amount equal to damages sustained by him in consequence of the belting's failure to come up to the representation. (Delaware Superior Court, E. F. Stoughton & Co. vs. Alpha Process Co., 93 "Atlantic Reporter," 669.)

Contributory Negligence of Engineer—A stationary engineer, like any other employee, must exercise a reasonable degree of care for his own safety and cannot recover against his employer for injury resulting from failure to do so. In applying this well-established legal principle in the case of Reid vs. Sloss-Sheffield Steel & Iron Co., 68 "Southern Reporter," 136, the Supreme Court of Alabama holds that an engineer, who knew of the increasing tendency of his engine to start automatically, on account of leakage of steam into the cylinders, although the throttle valve was shut off and the cylinder cocks open, and who unnecessarily rested his hand in a position where it would naturally be injured, while cleaning the engine, cannot recover for resulting injury.

Legal Duty Concerning Electric Lines—Although an electric power company, in constructing transmission lines along highways, must use a high degree of care to place the wires so high that travelers along the road will not be imperiled, it is not chargeable with liability for injury to one who attempted to pass under a line that was 27 ft. above ground with a hay derrick, that came in such close proximity to the wire as to become charged with electricity, where there was two inches' clearance and where it appeared that the particular wire was higher than many similar lines of other companies and that the presence of lower telephone wires along the road tended to induce a belief that all objects that could pass under such other wires would safely pass under the particular wire. (California Supreme Court, Fairbairn vs. American River Electric Co., 148 "Pacific Reporter," 788.)

Discharging Warm Water into Streams—Going somewhat beyond the doctrine that an owner of land bordering a stream is entitled to restrain an upstream owner from polluting the stream in such a manner as to injuriously affect the former's right to make reasonable use of the waters of the stream, the United State Corcuit Court of Appeals, Seventh Circuit, holds in the case of Dixon Pure Ice Co. vs. Sandusky Portland Cement Co., 221 "Federal Reporter," 200, that an ice company which derices a supply from ice freezing over a river abutting upon its land is entitled to enjoin an upper manufacturing company from casting into the stream water heated to so high a temperature that such ice is destroyed. Reconciling the respective rights of the parties, the court said:

> Complainant may not insist on such use of the water by defendant as will deprive the latter of any use thereof which may be necessary for its business purposes, provided complainant can by reasonable diligence and effort make the flowing water reasonably answer its own purposes. There must be a fair participation between them.
>
> The ice company was granted injunctive relief on a showing that the defendant took large quantities of water from Rock River in Illinois for cooling purposes in connection with condensing machinery and returned the same to the stream, heated to a temperature of 50 to 60 deg. The warm water, flowing 3125 ft. in about 2½ hr., prevented ice formation in front of the ice company's premises for a width in the river of about 100 ft.

NEW PUBLICATIONS

VALVES AND VALVE GEARS—By Franklin de Ronde Furman, professor of mechanism and machine design, Stevens Institute of Technology. Second edition, reset and enlarged. Published by John Wiley & Sons, Inc., New York City. Cloth, 253 pages; 6x9 in.; 237 illustrations. Price, $2.50.

This book, when first issued two years ago, referred chiefly to steam engines. In the present edition the first volume treats of valve mechanism applied to steam engines and turbines. A second volume (in preparation) will cover internal-combustion engine valve gears. The present volume should be adapted to the work of instruction because of the large number of problems and exercises given. The usual forms of slide, riding-cutoff, Corliss and other four-valve gears, are adequately described. A feature of the book is the complete treatment given to poppet, uniflow-engine and steam-turbine valve gears. The treatment of turbine gears includes a description of the De Laval mechanism, the hydraulic, steam-actuated and mechanical valve gear used on the Curtiss turbine and the direct, hydraulic or oil-operated relay and steam-operated relay used on the Westinghouse machines. The new material added in the present edition includes the semi-plug and high-pressure piston valves of the American Balance Valve Co., the Rice & Sargent-Corliss engine, including the Rites and Sargent governors and directions for setting valves and valve gears, the Nordberg valves and valve gears, the J. T. Marshall valve gear and the Sulzer steam-engine valve gear.

DISTRICT HEATING. A Brief Exposition of the Development of District Heating and Its Position Among Public Utilities. By S. Morgan Bushnell and Fred B. Orr. Published by the Heating & Ventilating Magazine Co., New York City. Cloth, 6x9 in., 290 pp., 82 illustrations and diagrams, unindexed. Price, $3.

The book is a general discussion of district heating, taking up the operation and construction of the central station, street-distribution systems, water, steam and condensation meters. It also gives methods of estimating heating requirements and describes the piping of buildings. A number of typical district steam-heating plants are described, and their methods of selling heat and the forms of contracts used are given. The preface states that the object of the book is to promote the interests of district heating companies. The general attitude taken in the text is illustrated by the final paragraph, which is quoted verbatim: "The great steam-boilers and turbines of central-power stations will produce a kilowatt-hour for the expenditure of a little more than one-fifth the amount of coal required in the central stations of 25 years ago, while the small installations have made comparatively little progress. In like manner the future may disclose corresponding economies that can be produced by the centralization of heat supply, thus making it a valued and profitable adjunct in the work of the public-utility company." The operating costs of isolated plant and central-station service are compared, the tendency being to dwell on what is said to be the disadvantages of the former and the advantages of the latter type of service.

POWER, HEATING AND VENTILATION. By Charles L. Hubbard, Published by the McGraw-Hill Book Co., Inc., New York. Cloth, 6x9 in. Part I—Steam Power Plants. 299 pp., 183 illustrations. Price, $2.50. Part II—Heating and Ventilating Plants. 308 pp., 207 illustrations. Price, $2.50. Part III—Combined Power and Heating Plants. 408 pp., 220 illustrations. Price $3.

The three volumes of this treatise consider the design, construction and management of plants as indicated by the titles given, and are a reprint of a set of three books by the same author and with the same general title which was published in 1908 and 1909. The present edition has been rearranged to a considerable extent and a few changes have been made. The section on electricity has been omitted and matter on steam turbines, power-plant design and economics added. Otherwise the original text and illustrations appear to have been retained.

Part I briefly describes boilers, engines and other auxiliary apparatus used in the power plant. Part II considers heating furnaces and boilers and heating and ventilating systems for all classes of buildings. Part III combines the material used in the first and second parts. The following review, while applying only to Part III, will therefore give an idea of the scope of the other two volumes.

The first chapter includes requirements for heating and ventilating office and loft, municipal and factory buildings, hotels, hospitals and theaters.

In succeeding chapters are discussed the relative merits of and data needed to design steam, hot water and hot blast heating systems. The methods of calculating and construct-

ing systems for transmitting heat from a central station to a group of buildings are somewhat briefly explained. The last 200 pages of Part III are devoted to the uses of power and steam in various types of large buildings, the selection and operation of boiler plants, use of engines and turbines and to a general discussion of condensers, pumps and other auxiliary equipment. The book concludes with examples showing the methods of calculating operating costs for a technical high school, hotel, machine shop and a hospital.

MECHANISM OF STEAM ENGINES. By Walter H. James, assistant professor, and Myron W. Dole, instructor of mechanical engineering, Massachusetts Institute of Technology. Published by John Wiley & Son, Inc., New York. Cloth, 170 pages; 6x9 in.; 183 illustrations. Price, $2.

This textbook has been planned to fill the gap between the study of the mechanism of steam engines and the study of the theory and practice of heat engineering. It is, therefore, an elementary treatise on the kinematics of steam engines, considering chiefly valves, valve gears and governing devices. The construction of typical examples of these parts is described and the method of laying them out is given. As is usual in works on mechanism, the relative motions of the parts are alone considered and no effort is made to trespass on the domain of thermodynamics or strength of materials. The ellipse, Zeuner, Reuleaux and Bilgram diagrams are explained, and their application and use in studying valve movements is given. The mechanisms treated include the D-slide valve, piston valve, riding cutoff, Corliss and other four-valve gears. The book is concluded with chapters on the steam turbine and on turbine valve mechanisms and governors.

CENTRIFUGAL PUMPS. By R. L. Daugherty, assistant professor of hydraulics, Sibley College, Cornell University. Published by the McGraw-Hill Book Co., Inc., New York City. Cloth, 6x9 in.; 192 pages; 111 illustrations. Price, $2.

Mr. Daugherty has briefly discussed the design, construction and operation of centrifugal pumps. One chapter is devoted to the general theory of hydraulics as related to centrifugal pumps; another takes up such theoretical considerations as angular momentum; torque, power and head imparted by impeller; and considers the value of the theory as applied to the practical pump. Two chapters are devoted to construction, describing the turbine and volute types of pump and taking up specific parts, such as impellers, diffusers and clearance rings. A number of tests made by the authors on two centrifugal pumps are recorded and are accompanied by a valuable analysis of the results. The speed, efficiency and cost of the centrifugal and displacement pumps are compared, as is the efficiency of the turbine and volute types of centrifugal pumps. A chapter gives data showing the relation between capacity and costs for stock centrifugal pumps and also a method for calculating the annual cost of pumping when the overhead and operating expenses are considered. In the final chapter is a discussion of the empirical procedure for determining the dimensions involved in the hydraulics of the pump.

ELECTRICAL MEASUREMENTS. By O. J. Bushnell and A. G. Turnbull, Meter Department, Commonwealth Edison Company, Chicago. Published by the American Technical Society, Chicago. Cloth, 171 pages, 6x9 in., 139 illustrations. Price, $1.

The book is a practical presentation of the operating principles of commercial electrical instruments. It shows their application to voltage, current, resistance and energy measurements. The first half is devoted to such instruments as galvanometers, ammeters, voltmeters and wattmeters. The well-known methods of measuring resistance are outlined, examples are given of resistance-calculations, and the ways of finding faults or grounds, of measuring insulation and battery resistances, are described. Some attention is given to instrument checking and calibration. The section concludes with valuable suggestions for preventing error with or injury to portable instruments. The second part of the book takes up instruments for measuring electrical energy. Nearly twenty pages are devoted to a general discussion of alternating-current distribution, circuits and metering methods. Next is given the operating principles, methods of installing, testing and reading watthour meters of the commutator, mercury motor and induction types. The book closes with a description of the instruments used in measuring maximum demand. Scattered through the text is material that should prove valuable to those using electrical instruments. It is therefore to be regretted that careless arrangement and indexing greatly lessen its value for reference purposes.

A Good Suggestion Still—How much exhaust steam does your manager sell to near-by shops and buildings? If he does not know it is feasible, and you do, why not suggest it?—from a back number of "Power."

NEW EQUIPMENT

ATLANTIC COAST STATES

The Manchester Traction, Light & Power Co., Manchester, N. H., has taken out a permit for a new power plant at Brook and Pennacook St., and also to enlarge its substation at Kelley's Falls.

A company is being organized at Milton, N. H., to be known as the Milton Electrical Co. A site has been secured for the location of the power house. It is reported that the city has entered into a contract for street lighting. J. B. Giguere is interested.

Local citizens of Brockton, Mass., have filed a petition with the Board of Aldermen asking for the appointment of a commission to investigate the feasibility of establishing a municipal electric-light plant in Brockton.

It is reported that the Millbury Water Co., Millbury, Mass., is considering changing the motive power of its pumping station from steam to electricity.

At a recent town meeting in Westfield, Mass., the sum of $25,000 was appropriated for the purpose of extending and improving the municipal electric-light plant.

It is reported that plans are being prepared for a new generating station and boiler plant for the Connecticut Power Co. in New London, Conn. The present buildings on the site will be removed and will be replaced by new ones. V. E. Bird, New London, is Mgr.

The Hermon Electric Light Co., Hermon, N. Y., is reported to be in the market for the purchase of an 8-kw. transformer. W. G. Popple is Secy. and Treas.

Endicott & Johnson, Lestershire, N. Y., manufacturer of boots and shoes, is preparing to double the output of its main power plant in Lestershire. A 2000-kw. steam turbine will be installed.

It is reported that the Westinghouse Lamp Co., Bloomfield, N. J., contemplates the construction of an addition to its power station in the Watsessing section.

SOUTHERN STATES

The Keyser Electric Light Co., Keyser, W. Va., contemplates the installation of new equipment in its plant, and increasing the output. N. J. Crooks is Mgr., Supt. and Cont. Agt.

The City Council of Kinston, N. C., is reported to be contemplating improvements to the municipal power plant to cost about $40,000. J. E. Weyher is Mgr. and Supt.

It is reported that the electric-light committee of Wake Forest, N. C., expects to purchase a 150-hp. boiler, one 125-hp. automatic or turbine engine, a 75-kw. three-phase generator, one exciter and one switchboard and feeder panel for the municipal electric-light plant. J. L. Bullard is Supt.

The Highland Film Corporation, Ft. Thomas, Ky., is reported to be contemplating the construction of a power plant to cost about $30,000.

CENTRAL STATES

It is reported that the Board of Commissioners of Montgomery County, Dayton, Ohio, has adopted a resolution providing for the construction of a new power house and the installation of new boilers at the Montgomery County Childrens' Home. The estimated cost of the work is $10,000.

The Kent Water, Light & Power Co., Kent, Ohio, will soon purchase a 72-in. by 18-ft. boiler. S. F. Messer is Mgr. and Supt.

The local electric-light plant at Corunna, Mich., a branch of the Consumers' Power Co., Owosso, was recently destroyed by fire at a loss of $15,000. C. W. Tippy, Jackson, Mich., is Gen. Mgr. of the Consumers' Power Co.

Bonds to the amount of $5000 have been voted for the purpose of installing an electric-light and power plant in Stephenson, Mich.

The City Council of Rockford, Ill., has instructed Ross P. Beckstrom, Supt. of Water-Wks., to investigate the feasibility and probable cost of establishing a municipal electric-light plant. Energy will be furnished for operating the city pumping station.

It is reported that the city of Luxembourg, Wis., is considering the installation of a municipal electric-light plant.

WEST OF THE MISSISSIPPI

It is reported that plans are being prepared for the installation of a municipal electric-light plant in Attica, Kan. The estimated cost is $15,000. F. H. Kelburn, Woodward, Okla., is Engr.

Bids will be received until Aug. 30 by the Village Clerk of Blair, Neb., for the construction of an electric-light plant. The Martz Engineering Co., First National Bank Bldg., Lincoln, is Engr.-in-Charge.

At a recent election the citizens of Franklin, Neb., voted in favor of issuing $7000 in bonds, the proceeds of which will be used for the installation of an electric-light plant.

The citizens of Shelton, Neb., have voted to issue $8000 in bonds for the purpose of establishing a municipal electric-light and power plant in Shelton.

The local electric-light and ice plant at Blue Springs, Mo., was recently destroyed by fire. Loss, about $9000. It is reported that plans are being made for rebuilding the plant.

The plant of the Redding Electric Light & Power Co., Redding, Calif., a subsidiary of the Northern California Light & Power Co., San Francisco, was recently burned at a loss of about $8000.

CANADA

The Town Council of Athens, Ont., has decided to install an electric-light and power plant. A. M. Lee is Clk.